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TP 5955E

FEASIBILITY OF APPLICATION OF THE UTDC TRANSPORTER AT VANCOUVER INTERNATIONAL AIRPORT

PREPARED FOR: TRANSPORT CANADA, TRANSPORTATION DEVELOPMENT CENTRE
DSS CONTRACT SERIAL NO: OSD84 - 00104
UTDC R&D REPORT NO: 334-990-003
DATED: 31 OCTOBER 1984

DISCLAIMER

The contents of this report reflect the views of the contractor and not necessarily the official views of Transport Canada's Transportation Development Centre.

EXPLANATORY NOTE

1) As the client for this study is aware, the possible Transporter system supplier (UTDC) has identified some further development and productionization tasks. The costs indicated in this report are predicated on the basis that this productionization and reliability demonstration work has been completed. In some cases, the technical solutions suggested for Transporter at the VIA in this report are those that would be tested during the other noted program.

2) The costs in this report are budgetary estimates for installing a system at VIA. They are not reflective of an offering price by UTDC and should the client or VIA authorities wish a supply proposal, UTDC would be pleased to provide one on short notice. A priced proposal by UTDC to supply the system would take into consideration the client's (i.e., Transport Canada's) chosen alignment and procurement strategy (This could be either a turnkey installation or separate civil works plus Transporter system contracts). The offering price would also reflect the chosen role of UTDC by the client with respect to Project Management. Further, an offering price would also have to reflect the client's interest in installing Transporter in other areas within it's jurisdiction. Decisions by the client to change or reallocate parking revenues, given the Transporter service, would also be reflected in a priced proposal.

PROJECT TEAM

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NORR AIRPORT PLANNING ASSOCIATES LTD.

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17. Abstract

The feasibility of applying Transporter technology to moving people and luggage from a remote parking lot to the Vancouver International Airport passenger terminal was studied. An additional application was identified, namely replacement of the existing shuttle bus service to the main parking lot.

Transporter technology is characterized by use of a resilient vehicle-mounted shoe riding in a concave rail to provide both support and guidance. The interface is supplied by low pressure air from within the rail, reducing friction to very low levels. Propulsion and braking are effected by means of guideway mounted linear induction motors.

A number of route and station options were examined, with the preferred route passing from the multi-purpose lot through the centre of the main lot with a terminal station located approximately at the existing shuttle bus stand. Operating costs of the system would be substantially lower than for an extended shuttle bus system serving both lots. Capital cost of the Transporter system will be in the order of $10,000,000. The major technical challenges are resisting wind loads and maintaining a clean support rail. The Transporter provides lower operating costs and an improved level of service to the parking lots relative to the present shuttle bus service. The deployment of a Transporter system at the Vancouver Airport is a feasible alternative to shuttle bus operation.

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17. Resume

Ce rapport rend compte de l'étude de faisabilité concernant l'utilisation de la technologie du coussin d'air pour les transports hectométriques de personnes et de bagages, entre l'aérogare de l'aéroport international de Vancouver et un terrain de stationnement éloigné desservant celle-ci. Cette étude a dégagé une autre utilisation intéressante du véhicule considéré: le remplacement de l'autobus-navette assurant la liaison entre l'aérogare et le terrain de stationnement principal. Le concept étudié par UTDC fait appel à un véhicule monté sur patins en matériau souple glissant sur rails concaves servant de support et de guide. Entre eux est créé un coussin d'air basse pression, alimenté à partir des rails mêmes, et grâce auquel le frottement est considérablement réduit. Quant aux fonctions de propulsion et de freinage, elles sont assurées par un moteur linéaire à induction placé entre les deux rails. Plusieurs options ont été considérées, prenant en compte divers itinéraires et points terminus. L'itinéraire privilégié a été celui qui part du stationnement éloigné, traverse la partie centrale du terrain de stationnement principal et aboutit non loin de l'arrêt actuel de l'autobus. Les coûts d'exploitation du système à coussin d'air ont été déterminés comme étant sensiblement moindres que ceux d'une navette par autobus dont le circuit aurait été prolongé pour desservir les deux terrains considérés. Le coût de premier établissement du système serait de l'ordre de 10 millions de $. Les contraintes à prendre principalement en compte sont les charges dues aux vents et le maintien des rails en état de propreté. Comparativement à la navette par autobus les avantages du système à coussin d'air sont des coûts d'exploitation moindres et un niveau de service supérieur. Dans le cas de l'aéroport de Vancouver, ce système se profile comme étant une solution de rechange intéressante, par rapport à la navette par autobus.

18. Mots-clés	19. Diffusion
Système à coussin d'air. Moteur linéaire à induction. Transports hectométriques. Transports en commun. Palettes sur coussin d'air.	Le CDT dispose d'un nombre limité d'exemplaires.

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1.0 INTRODUCTION

1.1 BACKGROUND

The project described herein, to determine the feasibility of installing the Transporter system at Vancouver International Airport, is follow-on work to previous Transportation Development Centre (TDC) projects. The Transporter is a lightweight automated guideway people mover system designed for the low speed, low capacity people mover market. It is new technology developed by UTDC R&D Ltd., and supported by TDC through two different projects.

The first study included a market review to determine possible application opportunities for air bearing technology in the transit industry and likely operational requirements. In addition, the establishment of an engineering study to determine preliminary system configurations and a general operating scenario of the system, including order of magnitude cost estimates, was undertaken.

This preliminary study concluded that the concept of marrying compliant air bearing technology with linear induction motor (LIM) in-track technology provides the potential for a high quality, low cost transportation system (the Transporter system) that would be very competitive with other systems developed for the low-capacity people mover market. A prototype system was built in an inside environment and demonstrated very encouraging results for further development. The study concluded that the potential reliability of the system, combined with the low capital and operating costs in comparison to competitive systems, creates the opportunity for a new product with large market potential. The report TP 4766E (Reference 1), prepared for DSS, identifies the level of marketing and engineering efforts that UTDC invested in the preliminary study program.

The second TDC project involves the actual development of an experimental Air Bearing Transportation System.

This project, which is now underway, includes the detailed design, construction and operational demonstration of an experimental Transporter system built at the UTDC Transportation Development Center at Kingston, Ontario. The purpose of the project is to demonstrate and evaluate the technical feasibility of the design solutions that have been developed through previous engineering efforts. The project cost of approximately $580,000 is shared equally by TDC and UTDC.

At this time, the construction of the experimental system is complete and the operational demonstration will be undertaken to evaluate the system performance in an outside environment. Some preliminary results are discussed in a later section of this report.

In addition to the projects outlined above, UTDC has also undertaken considerable work to further define and segment the low speed, low capacity people mover market, and to identify specific application opportunities. The Company has contracted outside consultants as well as utilized its own staff to evaluate the market. This work has provided the Corporation with considerable insight with respect to the market segments that will likely find automated guideway systems of interest, and the major performance requirements that must be achieved to meet the user requirements. One of the major potential markets identified by UTDC's market evaluation work is the airport market, whereby some type of shuttle system is required to transfer people short distances between parking areas and/or terminals.

1.2 FEASIBILITY STUDY OBJECTIVES

Overall Objectives

This project meets one of Transport Canada's objectives to increase the efficiency of the Canadian transportation system through improved intermodal transfer of passengers by identifying opportunities for systems improvements through terminal design, inter carrier scheduling and new technologies.

Project Objective

The specific objective of this project is to undertake a feasibility study for the installation and operation of the UTDC Transporter technology at the Vancouver International Airport to service their ground-side transportation needs.

1.3 STUDY METHODOLOGY

The study essentially had four phases. In the first phase data was gathered on the airport and its parking requirements. The airport site was visited and contact made with the staff to obtain drawings, traffic flow data and ascertain more clearly the needs of the parking system with respect to passenger demand. A number of options were generated with respect to route and terminal location which were reviewed with the Airport Staff at a meeting held 29 September 1984.

The core of the work then proceeded in two parallel paths with the people flow and station elements being studied by NAPA (Norr Airport Planning Associates) and the feasibility of applying Transporter technology being studied by UTDC R&D. The work culminated in a series of comparisons from a point of view of cost and service level between the Transporter and a competing shuttle bus service.

1.4 ORGANIZATION OF THE REPORT

The report follows in general the methodology of the study as defined in the Work Plan (Ref. 1). The initial part of the report, Sections 2 and 3, is taken up by a description of the Airport and its ground transportation needs and the technology of interest, the Transporter, respectively. Sections 4 to 7 are concerned with the core of the work, namely the generation of possible options for routes on the site, and a comparison of the Transporter system capability with both demand and the competing shuttle bus. Other potential applications in the Vancouver area are studied in Section 8.0. The report concludes with Conclusions and Recommendations in Section 9.0.

2.0 THE AIRPORT SITE

2.1 GENERAL

Vancouver International Airport is located on Sea Island adjacent to the Straight of Georgia, in the southwest corner of the Province of British columbia. Sea Island is 12 km south of downtown Vancouver, Canada's third largest metropolitan area and gateway to the Pacific. The siting of the airport on Sea Island, and its relationship to Greater Vancouver, are illustrated below in Figure 1.

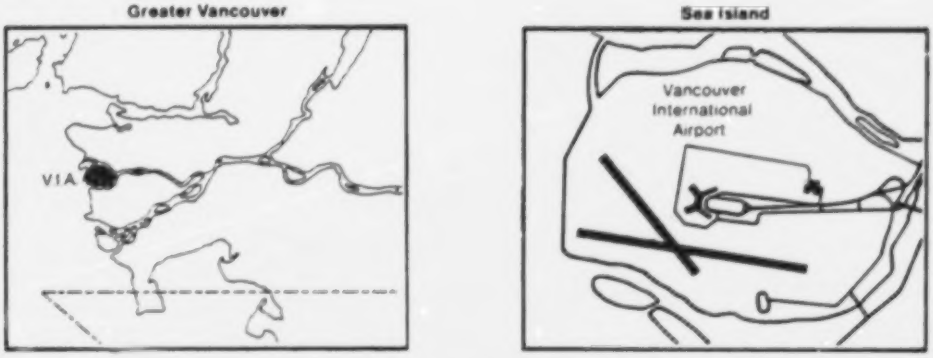


FIGURE 1: AIRPORT LOCATION

The Vancouver International Airport Master Plan, Reference 2, provides a series of basic guidelines for medium and long-term development, which will enable the airport to fulfill its function as an integral part of Canada's air transportation system. These guidelines are reflected in land use recommendations, which include the reservation of land in the 'airport centre' area, west of the Air Canada and C.P. Air Maintenance bases, for passenger terminal and air cargo development.

2.2 THE PASSENGER TERMINAL

The existing terminal configuration consists of a double-Y system of piers connected to a centralized processing area. Passenger processing takes place on three of the four levels of the building.

- Level 1 accommodates International and Transborder arrivals processing facilities. Although below grade, direct access is provided from the public concourse to the Level 1 roadway, curb and main parking lot, via steps and a ramp.

  (The International/Transborder arrivals facilities were provided as part of a mid-1970's modification program. This area was previously used as basement parking.)

- Level 2 accommodated Domestic arrivals and Transborder departures facilities. Direct access is provided from the Level 2 roadway and curb.
- Level 3 accommodates International and Domestic departures. Direct access is provided from the Level 3 roadway and curb.
- Level 4 accommodates airport and airline administrative accommodation, and provides access to the Control Tower above.

The Master Plan recommended that planning should proceed for the provision of additional terminal facilities to the north east, integrated with the existing terminal. This proposed Phase 1 development is illustrated in Figure 2. The need for further expansion (Phase 2) towards the end of the 20 year master planning period was also identified, as illustrated in Figure 3.

As the result of a drop in traffic forecasts since the completion of the Master Plan, the requirement to proceed with Phase 1 terminal expansion has been delayed. Recent activity in the field of deregulaton has resulted in the requirement for a new terminal to accommodate increased commuter traffic. A location adjacent to the southeast pier of the existing terminal is proposed.

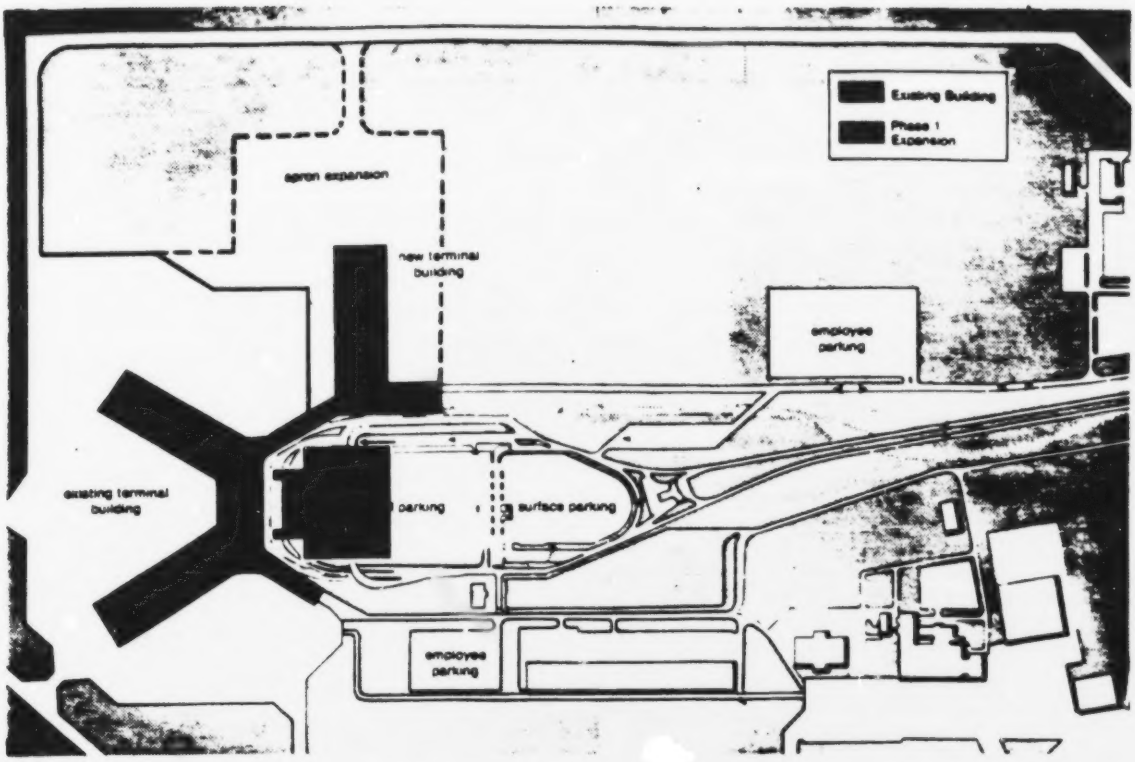
2.3 AIRPORT PARKING

The existing major surface parking areas consist of a public lot of approximately 2190 spaces (excluding meter and rental car parking), and two employee lots (to the north and south of the public lot), with 1100 and 400 spaces, respectively.

A new parking lot with 1843 spaces has recently been built to the north of the CP Air Service Road, west of the CP Air hanger. This lot is referred to as multi-purpose and will serve long-term public, employee and taxi-marshalling uses.

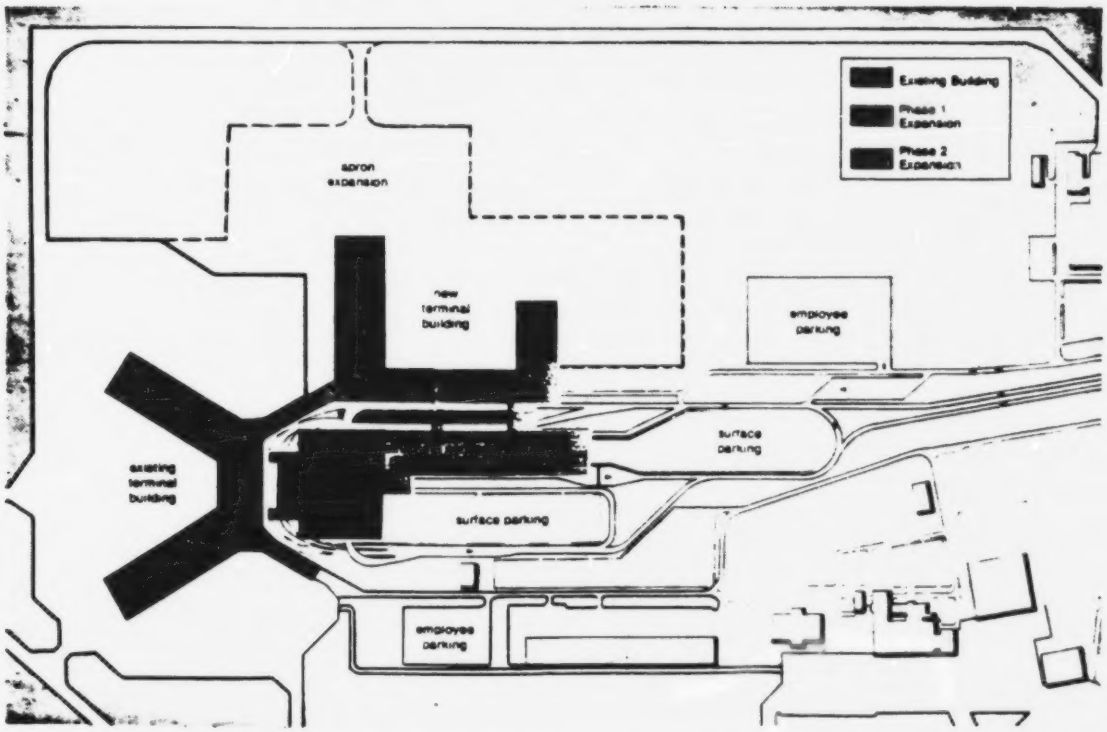
A shuttle bus service currently circulates between the Level 2 terminal curb and the public parking lot. The service operates normally on a 7-8 minute frequency and stops at six locations in the parking lot. During peak hours, frequency varies as the bus competes with automobile, taxi, bus and pedestrian traffic. Use of the bus is free of charge, and it runs 19 hours per day. As the multi-purpose lot has not yet been opened, no bus service is being provided to it.

The Phase 1 and 2 Terminal expansion plans (illustrated in Figures 2 and 3) show the introduction of structured parking in the public parking lot. Also shown is the relocation of the north employee parking lot, to a site in the same general area as the new multi-purpose lot, resulting from the new terminal expansion. Not shown is the impact that the proposed new commuter terminal will have on the south employee parking lot.



RECOMMENDED TERMINAL PLAN - PHASE 1

Figure 2



RECOMMENDED TERMINAL PLAN - PHASES 1 & 2

Figure 3

Source: VIA Master Plan (TP2375) Figures 16 & 17

2.4 TRAFFIC DEMAND

Air traffic forecasts for Vancouver International Airport were updated in 1983 by the Canadian Air Transportation Administration (CATA). Forecasts of passengers, aircraft movements and cargo have been produced for the period to 1991, and further projections have been made to the 2001. Excerpts from these forecasts and projections are reproduced below in Table 1.

TRAFFIC	1980 (Actual)	1991	2001
Annual origin + destination passengers	4,779,800	7,030,000	9,400,000
Annual enplaned + deplaned passengers	7,000,000	10,000,000	13,400,000
Planning peak day - total deplaned passengers	11,675 est.	16,500	22,000
Planning peak hour - total deplaned passengers	1,100 est.	1,490	1,900

TABLE 1: OFFICIAL CATA FORECASTS - VANCOUVER INTERNATIONAL AIRPORT

The forecast data most useful to system demand studies relates to planning peak hour and planning peak day origin and destination passengers. Unfortunately, these are not readily available and, hence, in Section 5.1 of this report we will discuss an alternative approach to system demand studies.

3.0 THE TECHNOLOGY

3.1 TECHNOLOGY DESCRIPTION

The technology considered for this application is identified by the generic name "Transporter" and consists of a system with the following elements:

- a lightweight, passive vehicle with no on-board propulsion power, which is propelled and guided automatically by guideway mounted systems;
- a LIM-in-track propulsion system, whereby Linear Induction Motors (LIMs) mounted between the support rails are sequentially energised to supply propulsion or braking in either direction;
- a control system which senses vehicle position and status, monitors subsystem performance, and controls the entire boarding, departing, cruise, braking and disembarking operation with multiple stops;
- a compliant air-bearing vehicle suspension system, which creates a cushion of air between the rail and suspension shoes, to reduce resistance to motion to a low level, but provides lateral guidance by the same mechanism.

The system is capable of being automated and run without direct human supervision. Each key system element is discussed further below.

3.1.1 Vehicle

The proposed vehicle would consist of a structurally stiff platform, reinforced longitudinally by the reaction rail assembly, with a non-structural passenger carrying shell. The vehicle would carry seated and standing passengers and be provided with luggage racks. Suspension would be via four articulated shoes. Coupling of vehicles in trains up to four units in length would be via couplings mounted on the reaction rail. The vehicle would be completely passive in a propulsion sense, but provided with passenger communications, emergency systems and lighting.

3.1.2 LIM Propulsion System

The propulsion system consists of a series of LIM stators mounted in the track, which consist of a stack of iron laminations wound with insulated copper wire. The moving magnetic field, created when the LIM is energised by alternating three phase current, induces eddy currents and magnetic fields in the secondary, mounted underneath the vehicle. The secondary or reaction rail typically consists of an aluminum facing sheet, of order 5 mm

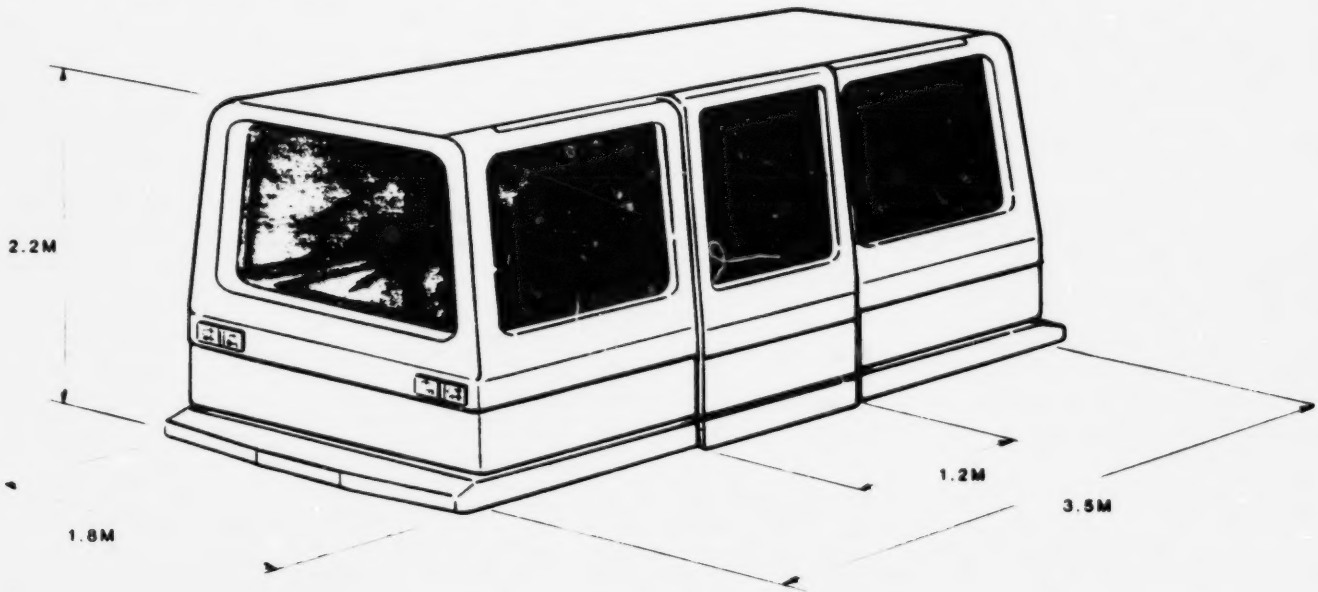


FIGURE 4: VEHICLE CONFIGURATION

UTDC

thickness, backed by an iron sheet of 3 to 6 mm thickness. This magnetic interaction results in both longitudinal and generally attractive forces between stator and reaction rail, which can be utilised to propel the vehicle. These forces vary with energising frequency, vehicle speed, air gap between stator and reaction rail and the physical parameters of the winding and materials used. Typically, each LIM is only energised for a brief period each time a vehicle passes, therefore, duty cycle may be very low, of order 5%. This results in a relatively small, low cost motor.

3.1.3 The Control System

The vehicle is passive, and all operational control, with the exception of emergency stop, is controlled from the guideway. Each LIM is equipped with sensors which determine vehicle direction and speed. Each LIM is sequentially energised to provide sufficient thrust to control speed to a preset value in the cruise sections between stations. LIM spacing may be varied, depending on requirement to climb grades or negotiate curves in the tracks in normal operation, plus a margin for severe weather and failure of an individual LIM. At the local level, the air sections are also supplied with air in sequence by the LIM controllers at the appropriate time. In each station, a local microprocessor controls final vehicle position, dwell and start up. Braking and acceleration are under a continuous closed loop control to a fixed speed profile at all weights and weather conditions. At the terminal or service area, a supervisory microprocessor monitors all systems and initiates corrective action, logs system problems and shuts down the system in a safe mode in event of an emergency.

3.1.4 Compliant Air-bearing

The system used consists of a hollow extruded rail with a central passage to which air can be supplied under a pressure of approximately 220 KPa. The air issues from the concave upper surface of the track and creates a pressurised cavity underneath a plastic runner, or shoe, which supports the vehicle. The hollow shoe is filled with cellulose cushion, which supplies both damping and acts as a spring medium. The air cavity itself is relatively thin, of order 0.25 mm, and the air escapes to atmosphere at the sides and both ends of the shoe through a gap, which is termed the "seal region", which is of order 0.025 mm under ideal circumstances. Thus, the shoe/rail combination provides a relatively low cost, light weight bearing (the pressurised cavity), guidance (the concave rail) and suspension (the shoe and filler).

3.2 PRELIMINARY OPERATING REQUIREMENT

A preliminary operating requirement, suitable for a system at the airport, was devised by discussion with the airport staff and consideration of the planning data provided. The requirements are summarised below:

- fully automatic shuttle operation and passenger demand mode;
- year round operation;
- two to four vehicles, to run coupled or individually;
- private right of way;
- maximum grade to be determined in the study;
- maximum curvature to be determined in the study;
- maximum velocity of 5 m/sec;
- maximum accel/decel 0.1 g, emergency deceleration 0.15 g;
- maximum jerk 0.1 g/sec;
- station and acceleration or braking sections on level; and
- nominal 30 second station dwell (see 334-510-001).

From a safety standpoint, provision must be made for:

- redundant braking,
- onboard passenger communication system,
- positive vehicle retention in vertical and lateral senses,
- provision for stops to prevent suspension overtravel, and
- vehicle recovery.

3.3 ENVIRONMENTAL CONSIDERATIONS

3.3.1 Requirements

All-weather operation is defined to be operation with a minimum of service interruption over the range of summer and winter temperature and relative humidity conditions and annual precipitation. These conditions for the airport are summarized below (References 3 & 4):

			97.5%	Extremes
o	Temperature Dry Bulb	- Summer High	+25°C	+33°C
		- Winter Low	-7°C	-18°C
o	Wet Bulb	- Summer High	+19°C	-
o	Precipitation	- Rain	1.055 m/year Total	
		- Snow	0.60 m/year Total	

The temperature range necessitates provision for track expansion, humidity requires a track air supply dryer system, and precipitation requires water drainage and some form of snow removal. Each is discussed below and, in addition, the effects of wind and track contamination are considered.

3.3.2 Track Heating System

Rain, either as discrete droplets, or collected in the rail trough, does not interfere with the air bearing action once air has been supplied to eject water from the centre passage of the rail. This can take up to a minute because of the reduced flow of water relative to air through the small air holes in the track surface. Thus, a wet or filled track can be cleared of water without any special provision other than a few minutes of air flow on each section before operation.

Large accumulations of snow or ice can be removed mechanically (e.g., shovel or snow blower), leaving a thin layer of compacted snow or ice on sensors, LIMs and in the concave rail surface. Similarly, freezing rain conditions would also produce a thin layer of up to 6 mm on these surfaces. Operation of virtually all proximity type sensors and LIMs is unaffected by such accumulations as long as mechanical interface is avoided. Ice and snow removal from the rail surface and, in the case of ice, potentially from the rail centre passage is also easily dealt with. Alternative means for achieving this are chemical de-icing, infra-red heat, plate-type resistance heaters, heat trace cable, parallel element electrical heater and heating of the air supply.

The demonstration track was constructed using the air heating system, but the lowest cost system for an extended route such as the airport would be a parallel element flexible heater mat under the base of the rail.

3.3.3 Air Supply Requirements

Operation at low ambient temperatures would allow internal icing of the air supply system if sufficient moisture were available in the supplied air from the compressor. Thus, an efficient air dryer with an outlet dewpoint of -40°C is needed to reduce air water content to 0.00008 kg H_2O/kg air.

3.3.4 Expansion Joint

The currently used rail is fabricated from hollow aluminum extrusion. The extremes of temperature to which it will be subjected causes expansion and contraction of each rail section (7.62 m long) at a rate of 25 x 10^{-6} m/m°C. For a realistic temperature range of -20°C to +40°C, this necessitates allowance for a total movement at each joint of 11.4 mm. Thus, typically the system would be assembled at +10°C, with a 6 mm gap at each rail joint, leaving a gap of 0.3 mm at +40°C and 11.7 mm at -20°C. In addition to allowing for the movement, air must be carried across the joint without leakage at all temperatures.

3.3.5 Shoe Design and Rail Contamination

Outdoor and all-weather operation imply a certain degree of debris tolerance for the system. The only critical area, with the exception of large objects, is the shoe-rail interface. Debris can be loosely classified into sticky and non-sticky substances. At this point, no testing of the tolerance to sticky substances has been carried out. Dry substances of small particle size are blown off the rail by the air, and large particles are brushed aside by the shoe. A shoe-mounted scraper blade and track brush for each shoe to clean the track can be installed. This will eliminate any particles which might potentially be trapped between the shoe and the rail.

3.3.6 Wind Loads

A brief examination of wind loads was carried out. Wind data for the airport was readily available, based on Reference 5. Two cases require consideration during design; namely, overturning the vehicle, caused by a combination of lift and side forces, and lateral derailing of the vehicle under side loads alone.

Previous studies for other transit vehicles have resulted in the general guidelines that for a typical box-like transit vehicle we should expect side force coefficients of 1.3, lift coefficients of 0.4, and that response to a two second gust should be considered. On Figure 5, the corrected wind speed data for the airport is compared to the wind speeds at which an empty vehicle

with no design provisions for external operation would derail or overturn. The relatively high frequency at which this would occur necessitates some form of positive vehicle retention. There are a number of simple means by which this could be achieved, and the most attractive concept is discussed in Section 5.3.2.

3.4 RIGHT OF WAY REQUIREMENT

The effects of shoe and rail contamination, when also taking into account safety requirements for an automated driverless system, necessitate a private right of way with grade separations. Based on the preliminary operating requirement and passenger demand levels expected, a vehicle with an approximate capacity of 16 passengers and luggage, is a good unit on which to base the guideway design. Such a vehicle would be 4.0 m long overall, 1.8 m wide and 2.2 m high and weigh 1000 kg empty, 2725 kg at crush load. To support this vehicle in curves, four articulated shoes, each of 1.8 m in length, are required, which will allow 200 m curves at a resistance coefficient of 0.05 (Ref. 6).

All stations are to be fitted with a form of redundant braking. The only limitation on grades is passenger comfort and a realistic level of installed thrust. A value of 6% for grades has been used for system design.

3.5 PRELIMINARY DEMONSTRATION RESULTS

At time of writing, the 40 m track has been installed outdoors for some 6 months and in daily operation for three months, totalling some 40,000 one-way trips. In terms of rail wear, this corresponds to eight months of 21 hours/day revenue operation at the airport site over a 1400 m track. Initially, rail wear "burn-in" occurred within the first 5,000 trips. Since that time, rate of rail wear has dramatically reduced, and the extent is not significantly different after a further 35,000 trips. Part of this relative improvement is due to the use of small shoe-mounted bristle brushes which clean the track immediately before the shoe. Operation of the track is possible in all wet or dry conditions.

Shoe wear has been modest. Shoes can generally be returned to service after cleaning. One set of 0.6 m shoes has been used for five weeks and 650 km.

3.6 TECHNICAL FEASIBILITY

The above considerations of the basic technology elements lead to the following conclusions when the considered application is a high availability airport service with relatively severe wind loads.

- o A vehicle retention system is required.
- o Some form of track cleaning or protection is required.

- Private right of way with 6% grades and 200 m radius curves is required.

There are no other fundamental requirements which cannot be achieved.

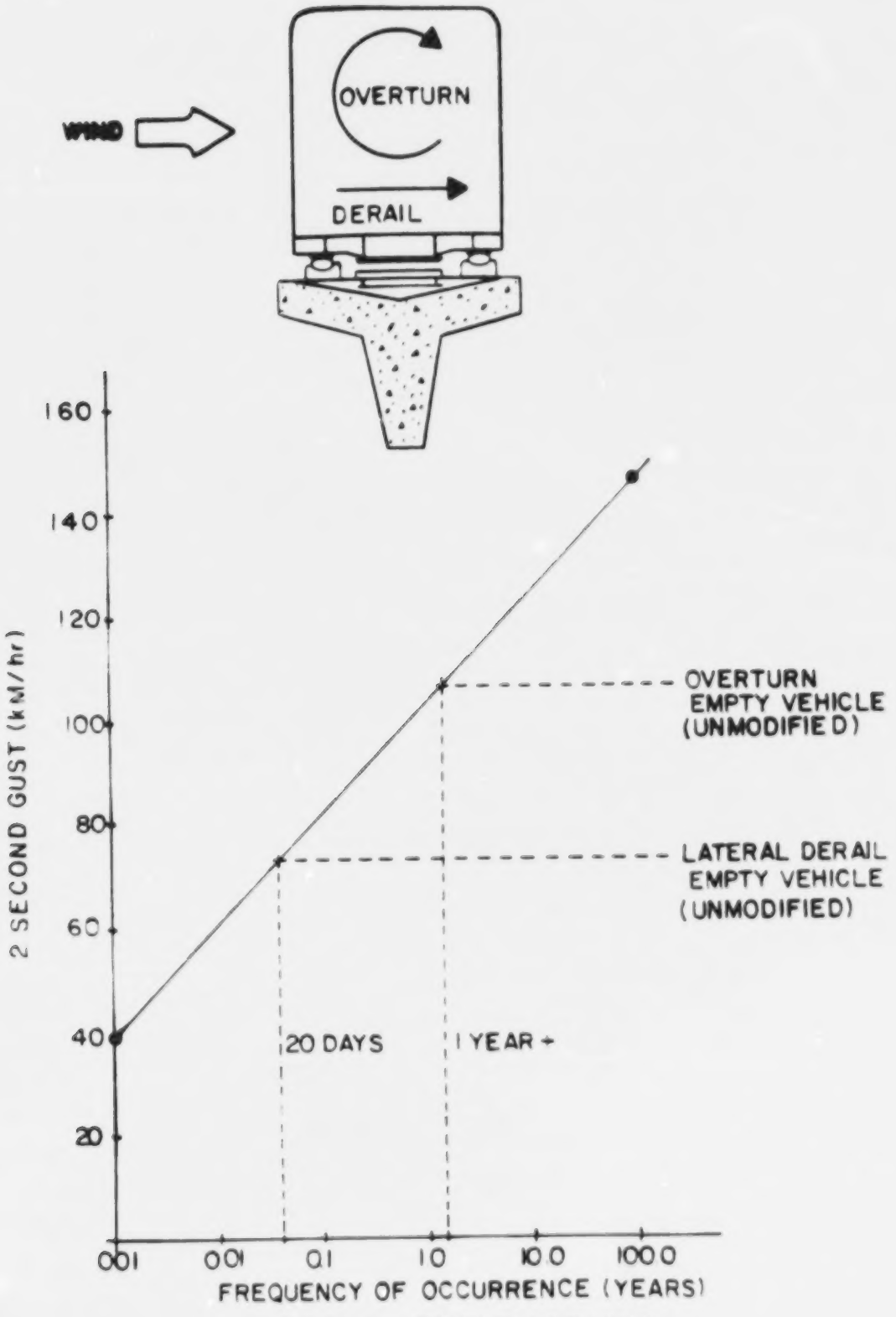


FIGURE 5: EFFECT OF WIND LOADS

4.0 ALTERNATIVE ROUTES AND THEIR IMPACTS

4.1 DESCRIPTION OF ROUTE OPTIONS

It was originally intended that alternative Transporter routings which would link the terminal with the new multi-purpose parking lot should be investigated. It soon became apparent, however, that the scope of investigation should be expanded to also include alternatives which linked the main parking lot and the terminal.

4.1.1 Option 1 (Figure 6)

This option links the terminal with the public and multi-purpose parking lots.

An elevated terminal station (with assumed connections to each of the processing levels) is linked to three grade level stations on the centre-line of the public parking lot; and then continues, via an elevated section of guideway, to two grade-level stations in the multi-purpose parking lot. The total length of the routing is 1400 m, of which 1000 m is elevated.

4.1.2 Option 2 (Figure 6)

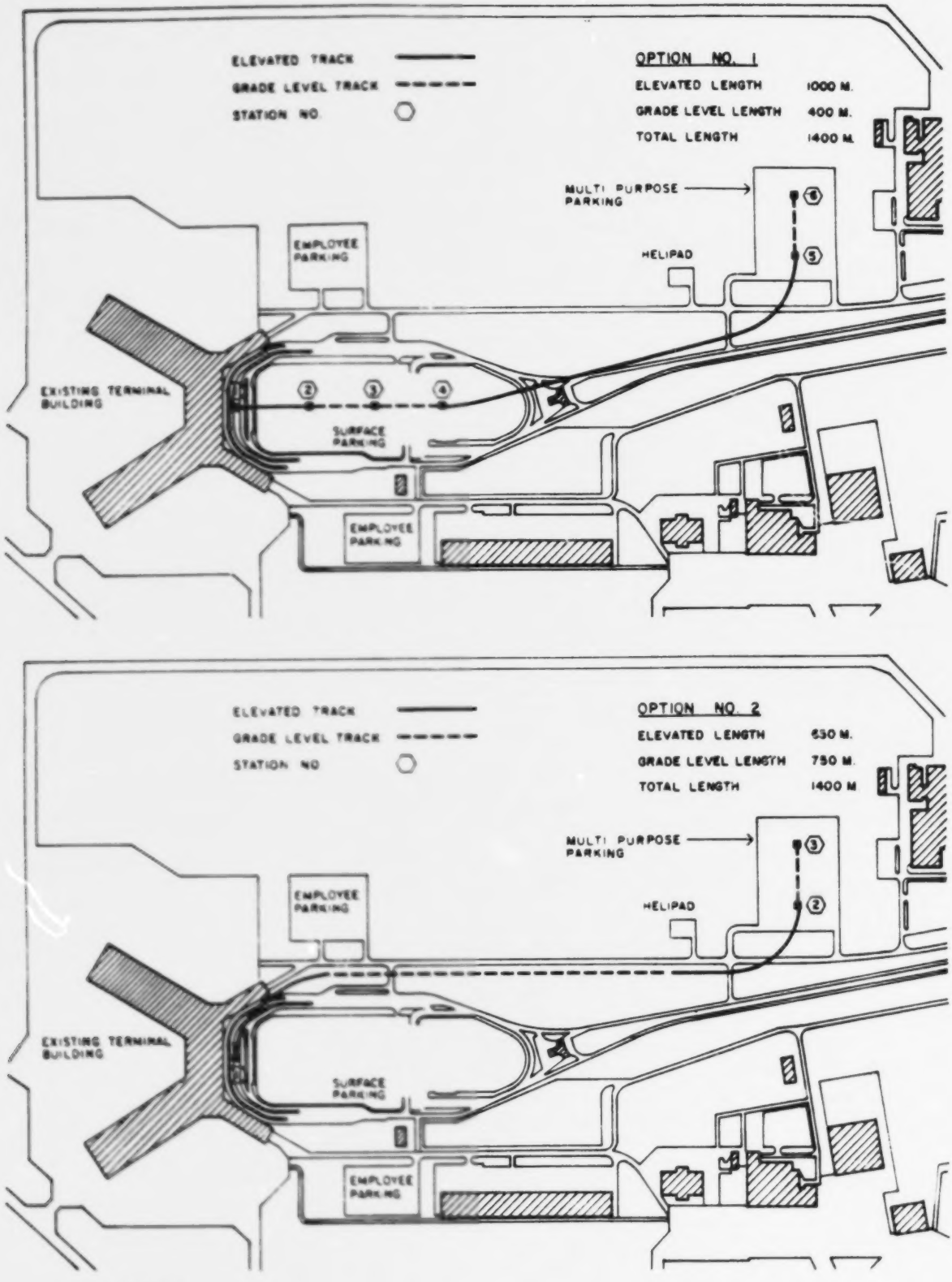
This option links the terminal with the multi-purpose parking lot only.

The routing commences at an elevated terminal station (with assumed connections to each of the processing levels); continues with a grade-level straight section of guideway located immediately south of the CP Air Service Road; becomes elevated and turns to the north as it clears the service road; and concludes with two grade-level stations in the multi-purpose parking lot.

4.1.3 Option 3 (Figure 7)

This option links the terminal with the multi-purpose parking lot only. Its prime objective is to illustrate a grade-level routing, which avoids the requirement for sections of elevated guideway.

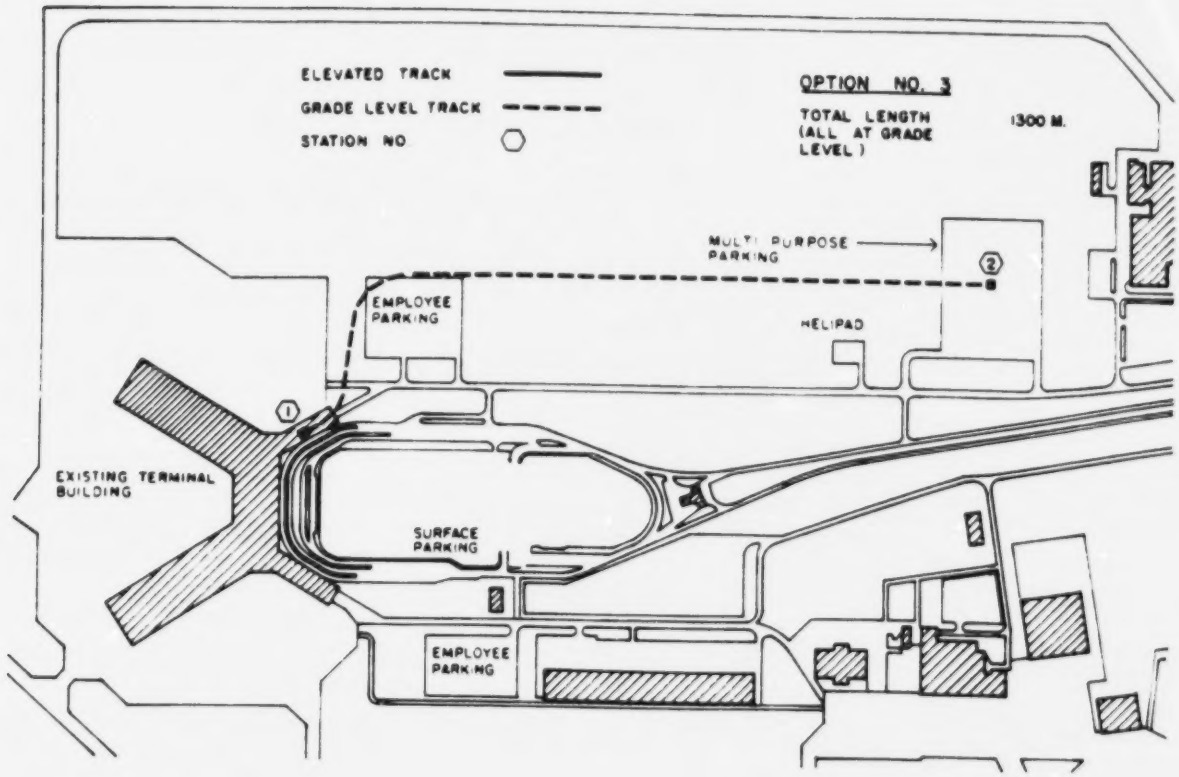
The routing selected commences at a station located in the terminal service road, crosses the CP Air Service Road at grade, takes an airside routing across the north employee parking lot, and then runs directly east to the multi-purpose parking lot, where it terminates in a single station.

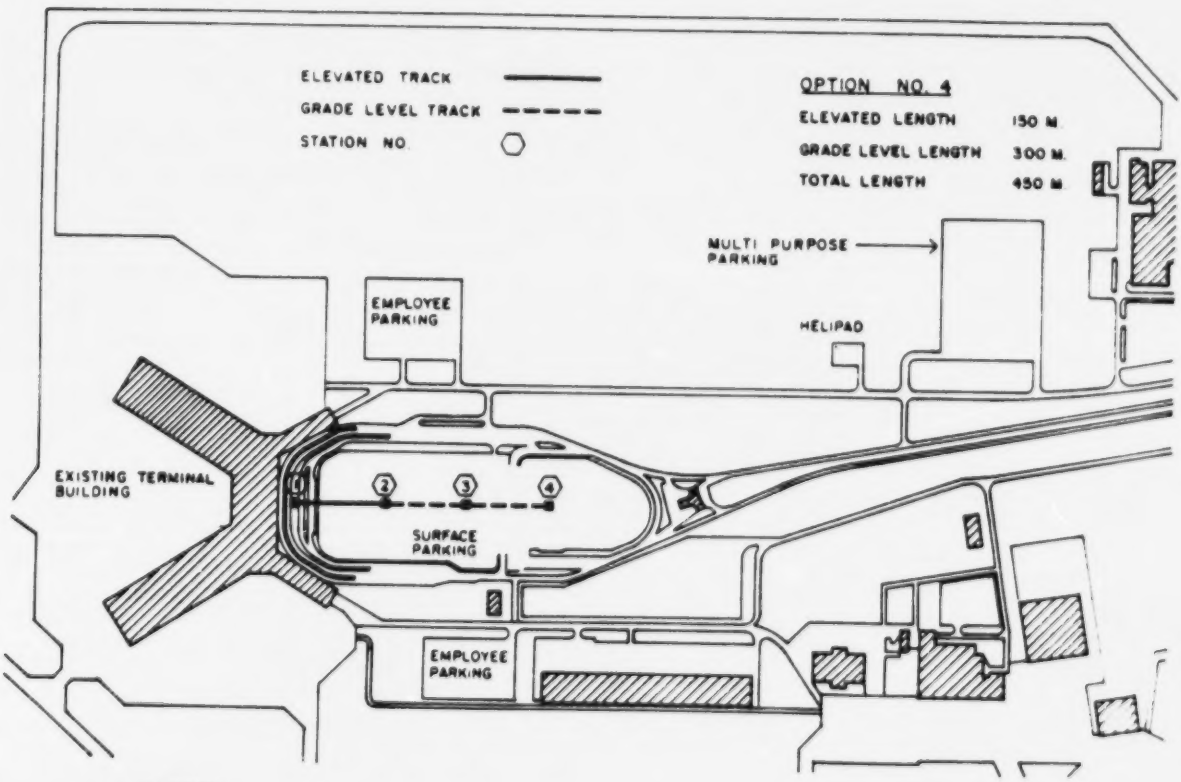


UTDC

ROUTE OPTIONS 1 & 2

Figure 6





UTDC

ROUTE OPTIONS 3 & 4

Figure 7

The routing conflicts with the land use recommendations of the Master Plan.

4.1.4 Option 4 (Figure 7)

This option links the terminal with the public parking lot only. Although it does not achieve the original objective of serving the multi-purpose parking lot, it could be used in combination with Option 2.

The routing commences at an elevated terminal station (with assumed connections to each of the processing levels) and continues with a grade level straight section serving three stations located on the central line of the public parking lot.

4.2 THE TERMINAL STATION

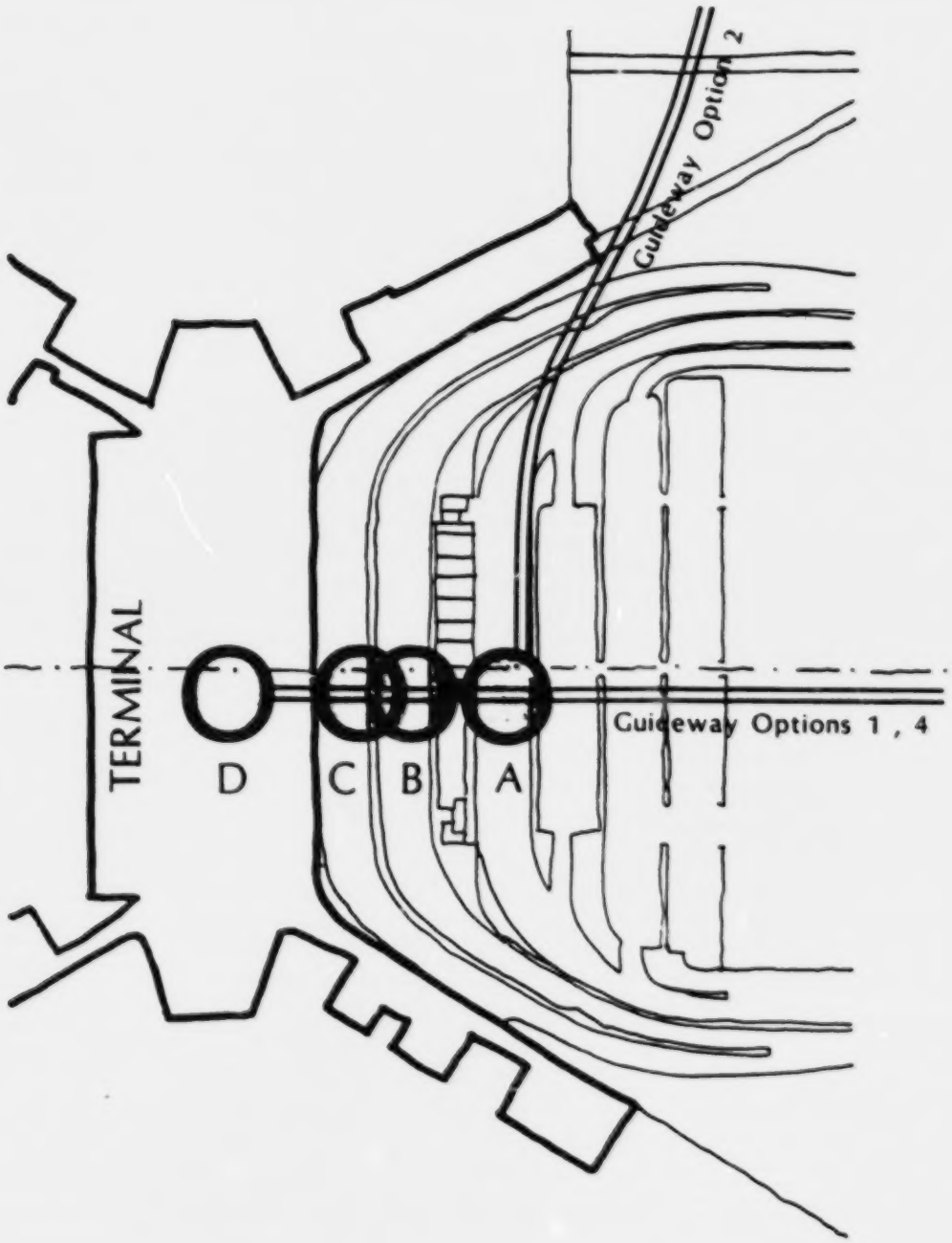
4.2.1 Route Options 1, 2 and 4 all commence with a Terminal station located approximately on the centre line of the terminal.

4.2.2 Route Option 3 commences with a station located in the existing service road at the north east end of the terminal. Initial assessment of this station location concluded that suitable public access could not be achieved from the Level 2 public concourse because of physical constraints caused by the U.S. Preclearance facility and an adjoining mechanical equipment room.

4.2.3 Terminal station alternatives investigated will, therefore, be concentrated on the locations illustrated in Route Options 1, 2 and 4.

For Options 1 and 4, four potential station locations, identified A, B, C and D, are available which provide a similar relationship to the east-west guideway routing. These alternatives are shown diagramatically in Figure 8. Only Alternative A is considered feasible for Route Option 3 because of problems in locating guideway supports in the other alternatives.

The diagramatic representations of each of the alternatives are developed in plan as overlays on part of the Level 3 floor plan of the terminal in Figures 9 to 12. The station platform is represented by a square of approximately 25 m (82 ft), from which connections are made to the various levels of the terminal. Floor to floor heights on the sections are exaggerated in order to clarify the flows between the station platform and the three floor levels of the terminal.



UTDC TERMINAL STATION LOCATION ALTERNATIVES

Figure 8

4.2.4 Station Alternative A (Figure 9)

The station platform is located above the Level 1 roadway. The interface of guideway Options 1 and 4 with the platform allows access and egress to occur on opposite sides of the Transporter. Guideway. Option 3 will require access and egress from the same side as the Transporter.

Direct connection can be made to Level 1 using stairs and/or escalators. Connections to Levels 2 and 3 (using stairs and a bridge, respectively) require people to walk across roadways before entering the terminal.

Walking distances from the Transporter (when stationary at the platform) to the terminal are increased by approximately 12 m (40 ft) to the doors at Level 2, when compared to the existing shuttle bus loading/unloading point. The distribution of public crossing to Level 2 road will, however, be different because of the direct connection from the platform to Level 3. At present, all people wishing to reach Level 3 from the public parking lot must enter the building at Level 2 and take the centre escalator/stair to Level 3.

Disabled/baggage cart access from the terminal to the station is via the bridge connection at Level 3. The proposed new central elevator system must be used to reach Level 3 by this traffic.

The impact of the station and its connecting links on the existing external structure and the building services is not significant when compared with the other alternatives.

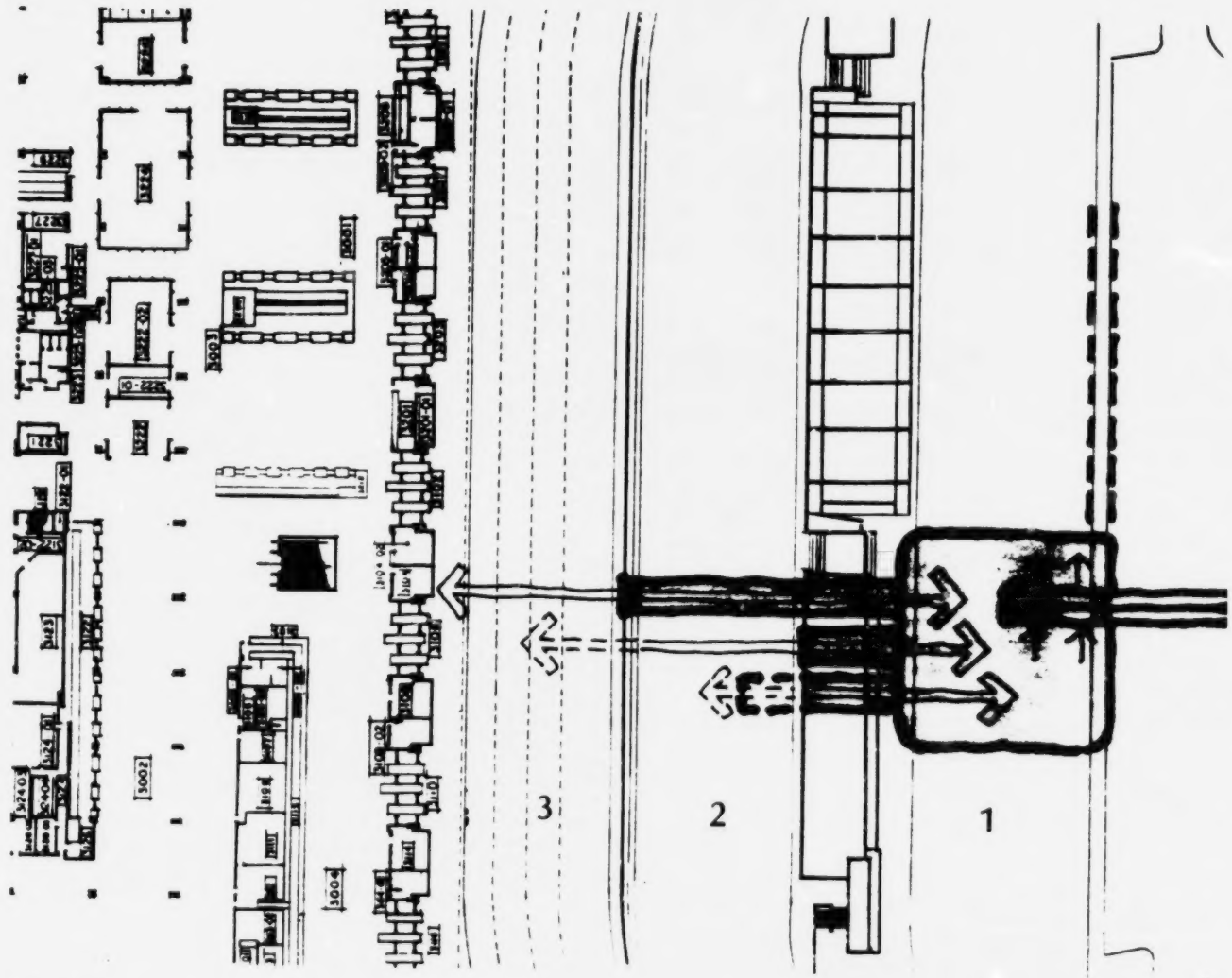
4.2.5 Station Alternative B (Figure 10)

The station platform is located above the Level 2 roadway. The interface of the guideway with the platform requires that access and egress take place on the same side of the Transporter.

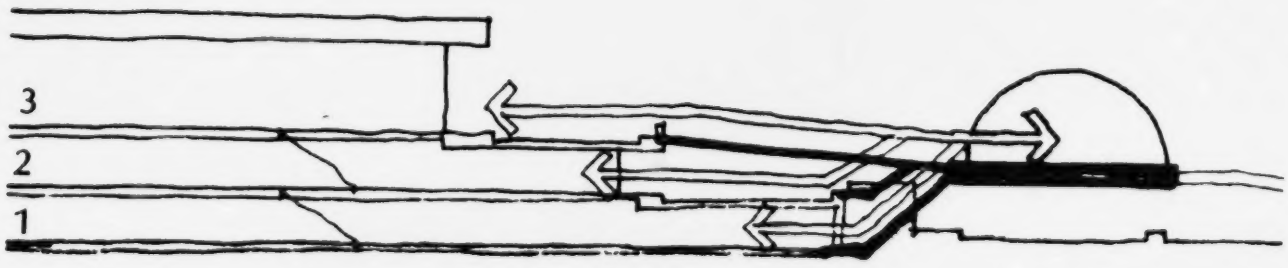
Direct connection can be made to Level 1 using stairs and/or escalator. The connection to Level 3 is across the roadway. Connections to Level 2 are indirect, requiring people to use the existing central escalators to transfer to Level 3 and then cross the road or, alternatively, to cross the Level 2 road and back-track up the stairs from Level 1.

Walking distances from the Transporter (when stationary at the platform) to the terminal are decreased by approximately 24 m(80 ft) in comparison with the route from the current shuttle bus loading/unloading point. The distribution of public walking to the various entry points to the terminal will be different from the current condition, being most concentrated on Level 3.

Disabled passengers and baggage cart access from the terminal to the station is across the road at Level 3. The impact of the station and its connecting links on the existing terminal would be



PLAN



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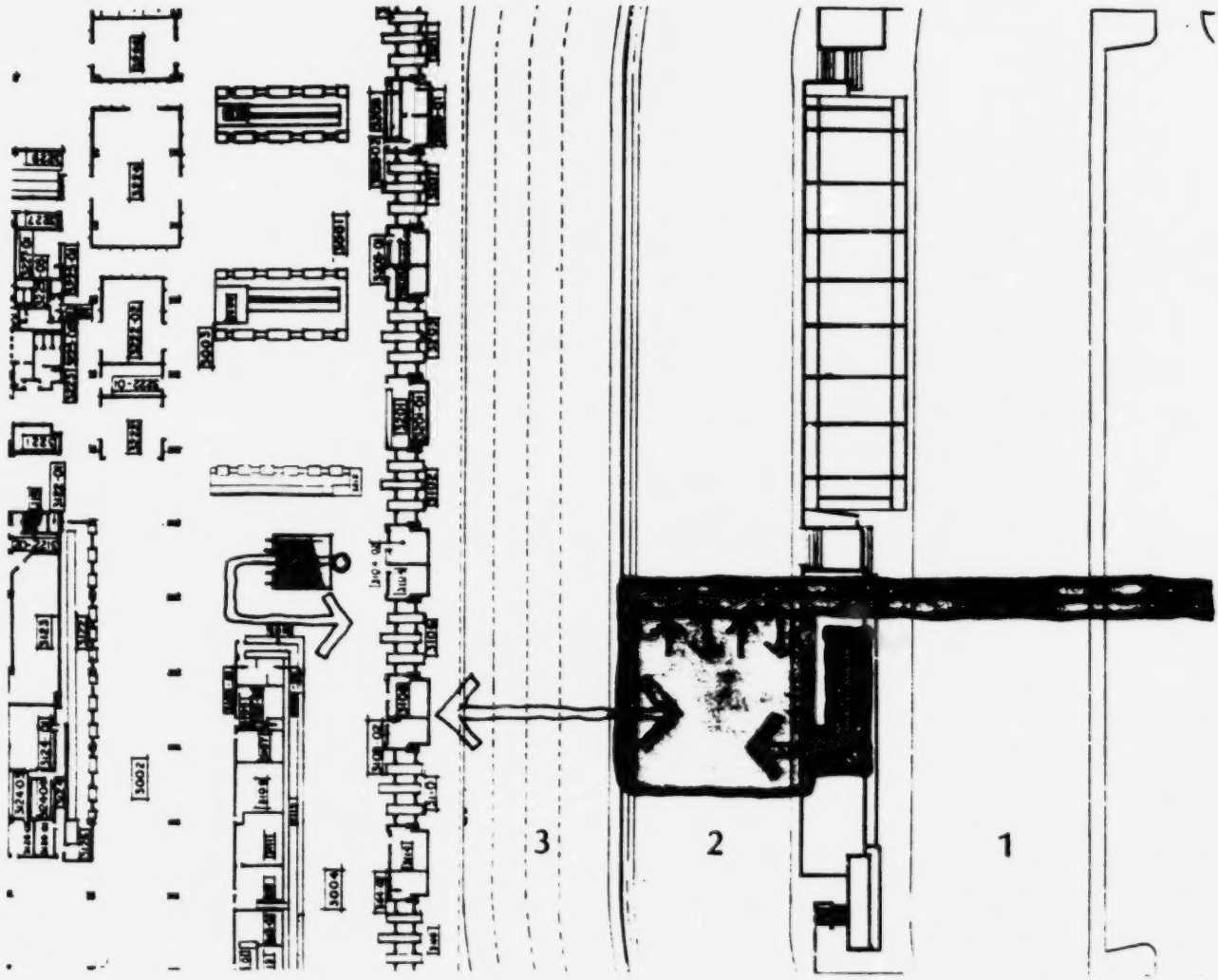
TERMINAL STATION ALTERNATIVE 'A'

Figure 9



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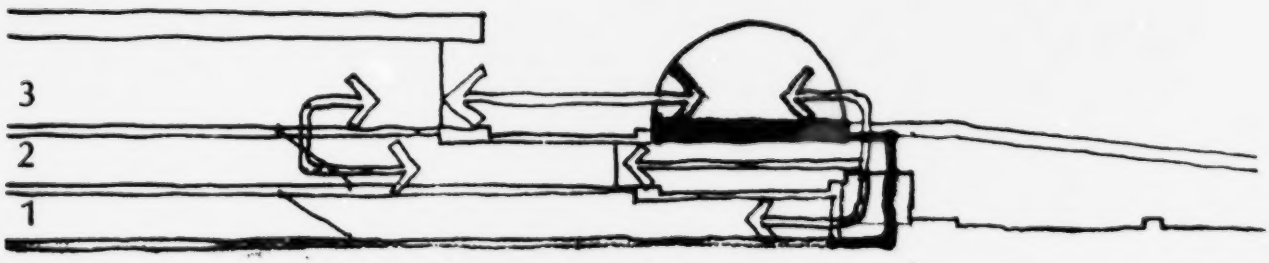

SECTION

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TERMINAL STATION ALTERNATIVE 'B'

Figure 10

fairly significant, in that the station will need to be supported by an independent structure which must penetrate through Level 1.

4.2.6 Station Alternative C (Figure 11)

The station platform is located above the Level 3 roadway. The interface of the guideway with the platform allows access and egress to occur on opposite sides of the Transporter.

Access to the platform is from a new mezzanine above Level 3. The existing escalator system and the proposed new elevator system are extended to this mezzanine in order to provide connections to all the levels below.

Walking distances to the station are significantly reduced in comparison to the shuttle bus, and all routes are under cover. Pedestrian traffic across the roads should also be significantly reduced, however, this traffic will be re-distributed onto the vertical transportation system in the terminal.

Disabled passengers and baggage cart access will use the proposed new elevator system (indicated diagramatically by a small circle on the plan), however, this system would need increased capacity to accommodate passengers with baggage, particularly if carts are to be provided.

The impact of the station on the existing terminal would be significant in that the station would need to be supported by an independent structure which must penetrate through Levels 1 and 2. In addition, structural supports for the guideway will also need to penetrate the existing structure.

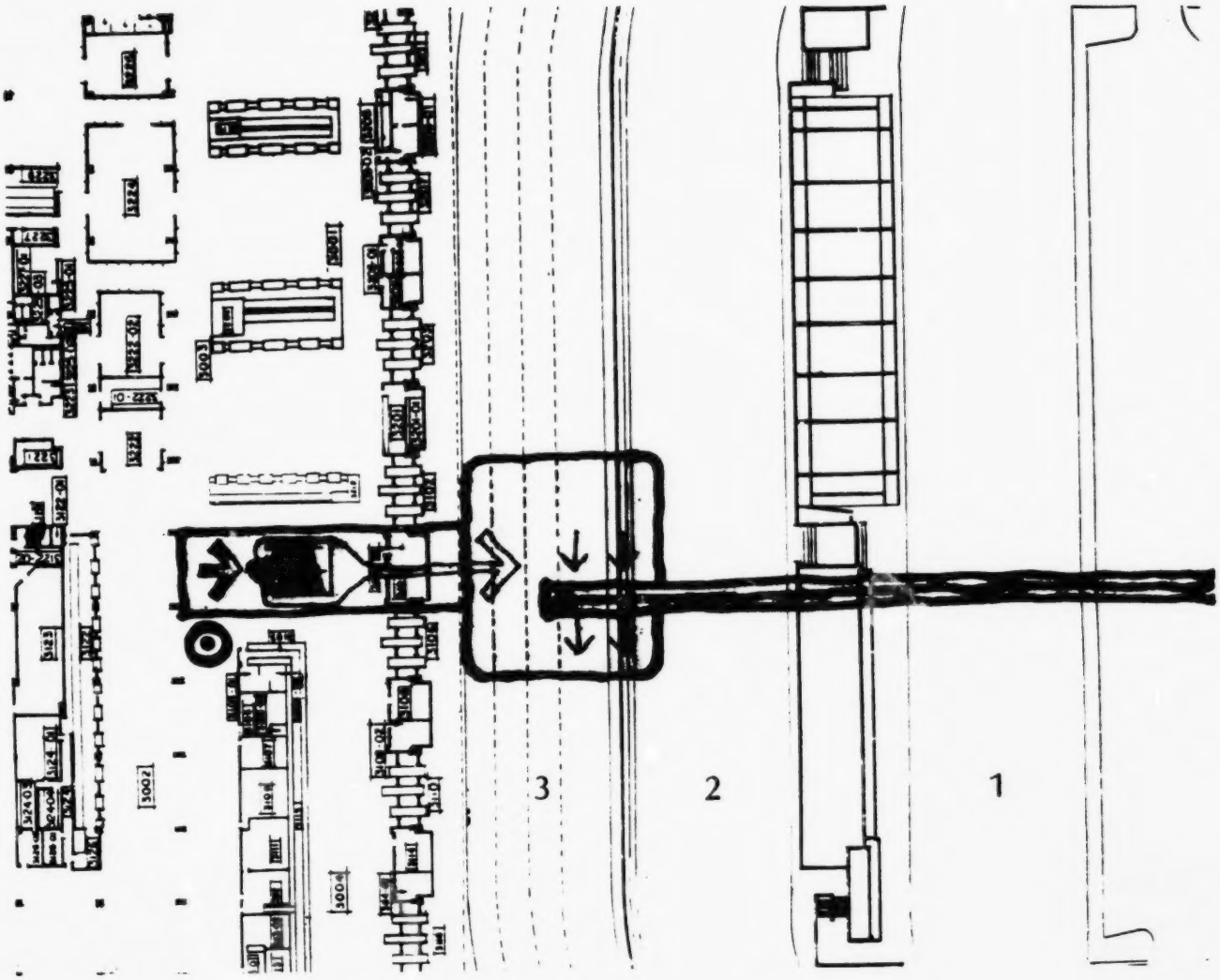
4.2.7 Station Alternative D (Figure 12)

The station is located on a mezzanine above Level 3. The interface with the platform allows access and egress to occur on opposite sides of the Transporter.

Access to the station will be via the existing escalator system, extended one bay to the west above Level 3, and also by the proposed new elevator system (indicated diagramatically by a small circle on the plan - location fairly flexible relative to the existing escalators).

As with Alternative C, walking distances to the station are significantly reduced in comparison to the shuttle bus, and all routes are under cover. Additional demand will be placed on the existing escalator system (and also on adjacent circulation routes), and the proposed new elevator system will need increased capacity to accommodate passengers with baggage carts, if these are provided.

The impact of the station and guideway on the existing terminal would be very significant because of their need for independent structural support through three levels.



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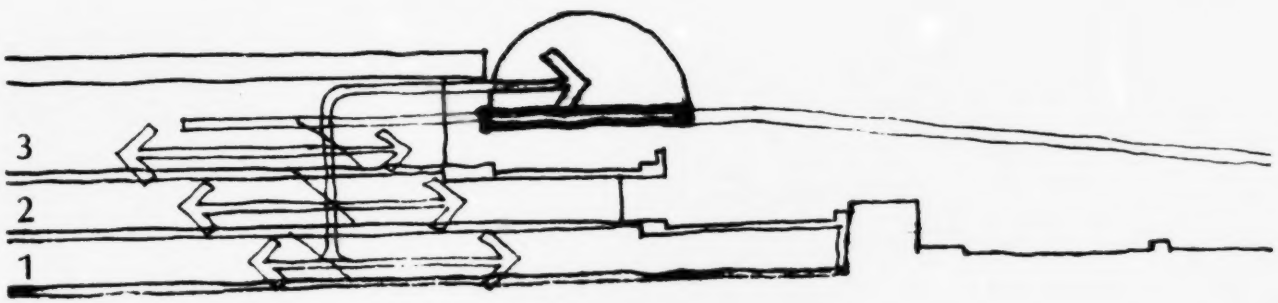

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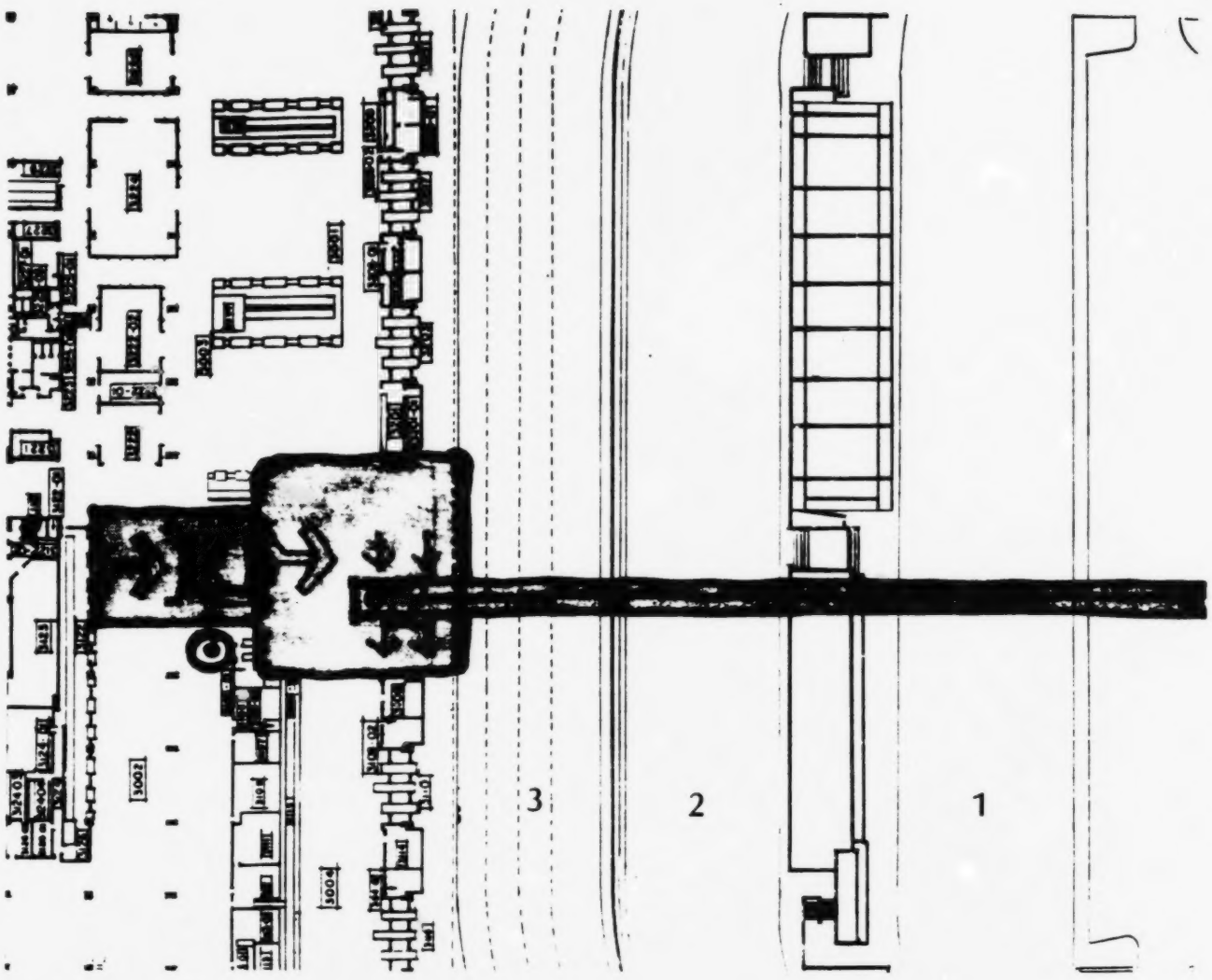
TERMINAL STATION ALTERNATIVE 'C'

Figure 11



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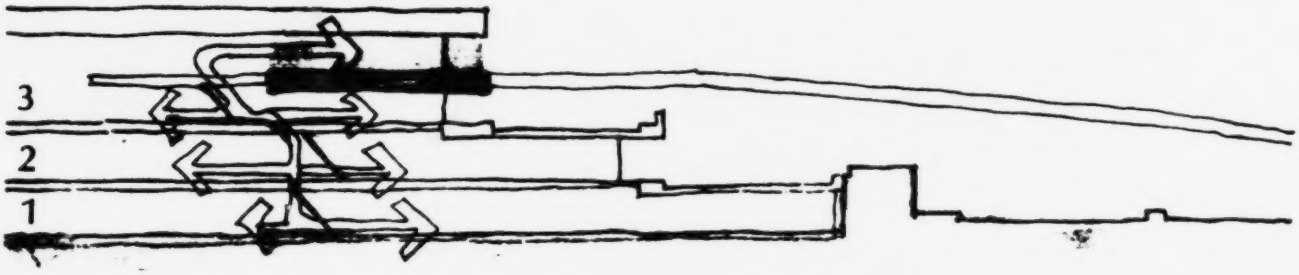

SECTION

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TERMINAL STATION ALTERNATIVE 'D'

Figure 12

4.3 IMPACT ON PARKING

4.3.1 General

The installation of the UTDC Transporter to serve the existing parking facilities will have a moderate impact on the physical layout of the facilities. More importantly, however, it will have a significant effect on the operation of the facilities.

4.3.2 Impact on Public Parking Lot

The installation of the Transporter system within the main public carpark (as in Route Option 1) will be at grade through the central part of the carpark, with the Transporter guideway being grade separated at the west and east ends of the carpark where it crosses the Level 1 terminal frontage road on the west and the Grant MacConachie Way on the east. The guideway, centrally located within the parking lot, will effectively bisect the existing carpark into two sections, one to the north and the other to the south. As a consequence, the public carpark will, in essence, operate as two separate parking lots.

Because of this split operation, measures need to be instituted to ensure an equalized utilization of the two parking areas. In all likelihood, the north portion of the lot would tend to fill up first, since it is more immediately visible with the parking entrance being situated on the north side. As a consequence, changeable message signs need to be provided at the parking entrances to instruct parkers to use the south lot when the north lot is close to capacity. This would also involve the provision of appropriate guidance signs in addition to ways of measuring the level of parkers using the north lot, so that the changeable message sign is activated automatically.

In terms of physical impact, the Transporter guideway does not have a profound effect on the existing parking facility, as the existing surface lot can be easily reconfigured. To this end, two basic alternative schemes have been developed:

- Scheme A (Figure 13) - which proposes a parking arrangement in a longitudinal configuration similar to the present, and
- Scheme B (Figure 14) - which proposes a transfer parking arrangement with respect to the guideway alignment.

Although the introduction of the Transporter guideway within the public carpark will consume a certain amount of space,by rearranging the parking layout as shown on Scheme A, it is possible, in fact, to increase the number of parking spaces available within the carpark. By using 90° parking with 2.75 m wide stalls and 18 m separation between parking modules (similar to the existing layout), the public parking capacity can be increased by about 27%, from 2190 spaces to 2800 spaces. However,

with this layout, pedestrians will need to cross a number of traffic lanes, depending on where the vehicle is parked, in order to reach the Transporter station and vice versa. Also, parkers will need to walk between parked vehicles, unless special pedestrian crossings are provided at selected intervals, to facilitate pedestrian movement.

With Scheme B, total of 2570 parking spaces can be provided, an increase of 17% over the existing. This arrangement will entail one-way vehicular flow along the parking aisles. Pedestrian movement between the parking lot and the Transporter stations will be facilitated with this arrangement, since the number of vehicular/pedestrian conflicts are reduced and transverse pedestrian walkways between parking rows can easily be developed (either raised, e.g., sidewalks, or at grade) to enhance pedestrian circulation even more.

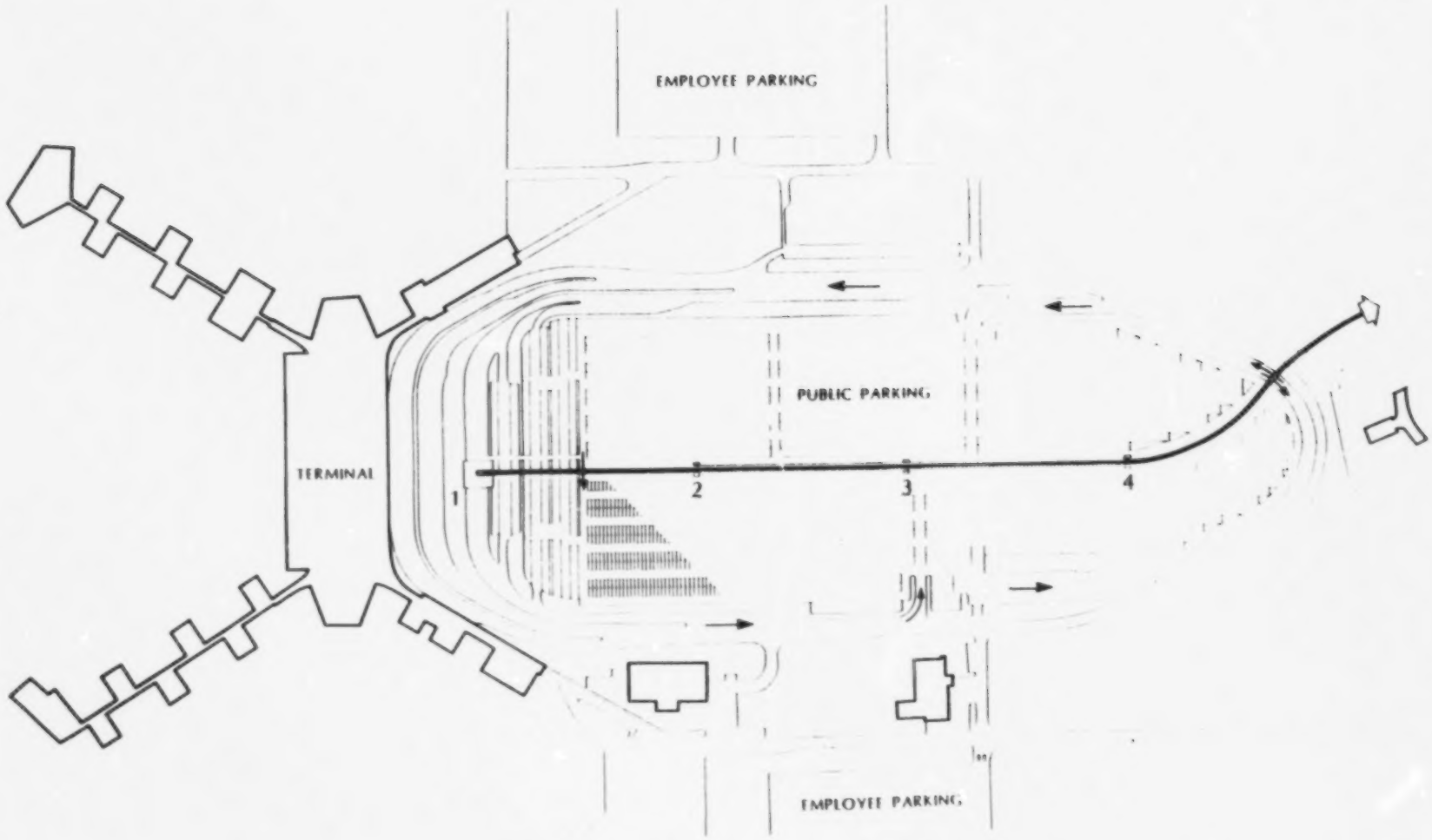
4.3.3 Impact on Multi-Purpose Parking Lot

The multi-purpose carpark is presently providing 1843 parking spaces. The installation of the Transporter guideway along its centre (as in Route Options 1 and 2) will eliminate some 80 spaces, so that the resulting parking capacity will be reduced to 1763 spaces, representing a minimal reduction.

Operationally, the multi-purpose carpark will be affected similarly to the public carpark, in that it will be physically separated into two sections. Again, some method of ensuring a balanced utilization of the two sections needs to be devised. This can be accomplished by a combination of traffic counters which can measure inbound and outbound traffic movements and changeable message signs, which can direct the parker to use one or the other of the two parking sections.

4.3.4 Net Effect

Installation of Transporter would require some reconfiguration of both parking lots and results in a minimum net increase of 300 spaces and a maximum net increase of 530 spaces depending on the configuration selected.



PUBLIC PARKING RECONFIGURATION - SCHEME 'A'

Figure 13

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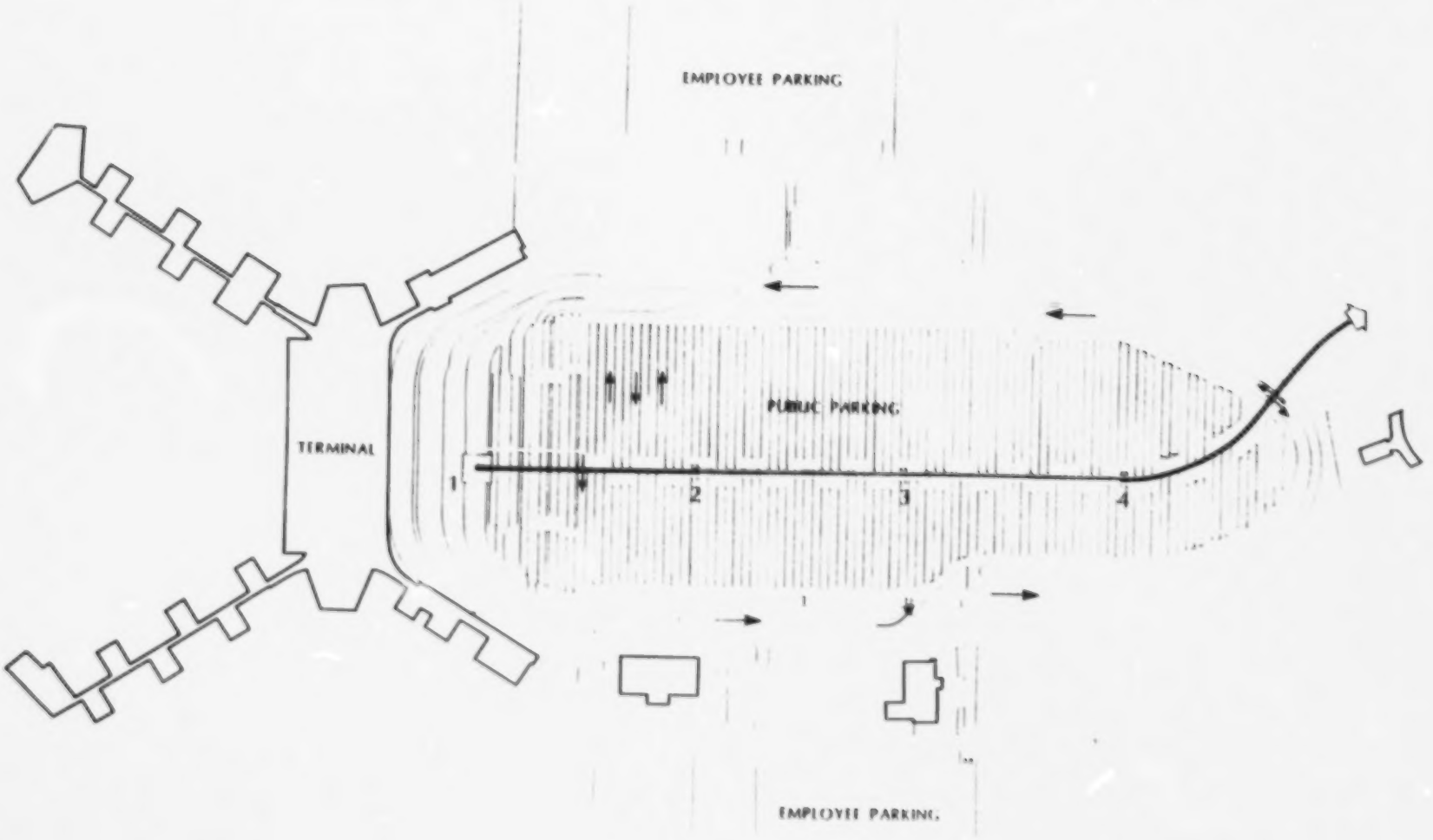

PUBLIC PARKING RECONFIGURATION - SCHEME 'B'

Figure 14

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5.0 SYSTEM STUDIES

5.1 SYSTEM DEMAND

5.1.1 Assumptions

In Section 4, four optional routes for the Transporter system were discussed. The main differences between the options were related to whether the system would serve either the multi-purpose remote lot alone, the main public parking lot alone, or both the multi-purpose and main lot together.

Sufficient data to carry out a definitive system demand study for Vancouver not being available, a modified approach has been used to estimate the maximum demand that would be imposed on the system. The main assumptions used in this approach are summarized below:

- In calculating the maximum demand on the system, the multi-purpose lot and the main lot are first treated separately, and then combined for the calculation of total system demand.

- It is assumed that the maximum demand on the system will be supplied when the parking lots are at the peak of their respective practical capacities. The practical of each lot are assumed to be 85 percent of the total number of parking spaces provided.

- The peak hour demand on the Transporter will be supplied by passengers, well-wishers/greeters and employees who park in the lots and travel to and from the terminal building.

- The required statistics for Vancouver relate to the relationship between parking accumulation and peak-hour entry/exit volumes. This type of information would best be supplied through a ground transportation and parking survey such as the survey carried out for Toronto's Terminal 1 and 2 in 1980.

Because such data is unavailable to us, we have attempted to transpose data collection at Toronto to the Vancouver site, recognizing the potential pitfalls of such a transposition. We know that one of the primary factors affecting the validity of this type of data transposition is the degree of similarity that may exist between peaking characteristics at the two airports. Another of the important factors is the similarity of sector splits between the two airports, as we know from experience that an airport's parking requirements are closely related to the sectors which the airport is servicing.

To illustrate the similarities in peaking characteristics between VIA and PIA's Terminal 1 and 2, data has been extracted from the Official CATA Forecasts and presented in Table 2.

From this Table, it would appear that there is a relatively close match between VIA and PIA Terminal 2. Whereas the daily peak is 6 percent less pronounced at Terminal 2, the planning peak hour is 12 percent more pronounced. Terminal 2 provides a better match than Terminal 1 and, in the content of this study, absolute values are close enough to permit the transposition of groundside survey data from Terminal 2 to VIA judging by the peaking criterion.

STATISTIC	VIA	PIA	
		T1	T2
Annual origin and destination passengers (AODP)	4,779,800	5,219,800	5,663,300
Annual Enplaned and deplaned passengers (AEDP)	7,000,000	5,795,300	8,726,700
Planning peak day deplaned passengers combined all sectors (PPDDP)	11,675	8,258	13,715
Planning peak hour deplaned passengers combined all sectors (PPHDP)	1,100	1,001	1,451
$\frac{PPDDP \times 2}{AEDP}$	.0033	.0028 (-15%)	.0031 (-6%)
$\frac{PPHDP}{PPDDP}$	.0942	.1212 (+29%)	.1058 (+12%)

TABLE 2

Comparison of Traffic Statistics at Pearson and Vancouver International Airports - Peaking Characteristics 1980

In Table 3, a comparison of sector splits between VIA and PIA's Terminal 1 and 2 is presented, this time from data related to 1979 statistics. Again, Terminal 2 statistics exhibit a closer fit to

VIA statistics in turns of sector splits. This reinforces the validity of transposing groundside survey data from Terminal 2 to VIA, judging by the sector split criterion.

Planning Peak Hour Deplaned Passenger by Sector (1979)	VIA	PIA	
		T1	T2
International Individual Sector Peak	548	723 (+32%)	640 (+17%)
Transborder Individual Sector Peak	415	453 (+9%)	414 (+0%)
Domestic Individual Sector Peak	889	450 (-8%)	1,000 (+36%)
Combined	1,075	990 (-8%)	1,457 (+36%)

TABLE 3

Comparison of Planning Peak Hours Sector Splits between VIA and PIA's Terminal 1 and 2 - 1979 Statistics

5.1.2 Calculation of System Demand - Public Parking Lot

From the 1980 Groundside Survey at Toronto, the average accumulation of parking at Terminal 2 as surveyed over five week days during the month of July was 2,482 spaces (short-term plus long-term spaces).

The average inbound and outbound peak hour traffic volumes surveyed at the Terminal 2 parking garage over the same five week days was 586 and 646 vehicles per hour respectively.

Hence for every space occupied there were an average of .236 and .260 vehicle movements per hour inbound and outbound respectively. It is these ratios that will be transposed to Vancouver to estimate the number of vehicles entering and leaving the parking lot. By assuming an average vehicle occupancy, it is possible to estimate the number of Transporter passengers per hour that would use the system, based on 100 percent ridership. Because all routing configurations under consideration would operate in the shuttle mode, it is necessary to estimate the peak loading regardless of direction. In this case, the operative ratio used to estimate peak loading will be the exit ratio i.e. for arriving passengers and their greeters.

Scheme B for the Public Parking Lot, as discussed in Section4.3.2 of the report would provide a total of 2,380 spaces. Assuming 85 percent utilization as its practical capacity, a total maximum accumulation of 2,023 vehicles is estimated. This value of 85% is typical for large public parking lots. The number of outbound vehicle movements associated with this maximum parking lot capacity is 2,023 x .260 or 526 vehicles leaving the public parking lot in the peak hour.

Assuming an average vehicle occupancy of 1.5 passengers per vehicle, the estimated maximum demand on the Transporter is therefore estimated at 789 passengers per hour on the outbound run, assuming 100 percent ridership. Because a number of short-term spaces are located between the closest public parking lot station and the terminal station, it is unreasonable to assume that all passengers/greeters using these spaces will backtrack to the station in the parking lot and ride the Transporter to the Terminal station. Furthermore, it is unreasonable to assume 100 percent ridership from passengers who are parked in the central part of the public parking lot. For these reasons, design ridership for system selection has been assumed at 70 percent.

Maximum Transporter system demand for the public parking lot has therefore been estimated at 70 percent of 789, or 550 passengers per hour.

5.1.3 Calculation of System Demand - Multi-Purpose Parking Lot

This calculation is made problematic by the fact that the lot is not currently in use, and secondly because the ratio of users (long-term public/employees/taxi holding) has yet to be established.

If the main users of the lot were employees, we could expect to experience heavy surge loadings at shift change time slots. If these time slots overlapped with peak periods in the nominal schedule for the peak planning day, the system would be taxed by a superimposed load emanating from long-term public parking users.

The total number of spaces available in the multi-purpose lot is 1,843 less 80 spaces deleted because of guideway right-of-way requirements. An assumption has been made that 100 of the remaining spaces would be turned over to the taxi holding area leaving a net capacity of 1,663 spaces for employees and long-term maximum practical capacity of the multi-purpose lot would be 1,414 vehicles.

To calculate the Transporter system demand at maximum practical parking lot occupancy levels, a number of simplifying assumptions have been made regarding use of the lot based on discussions held with the airport staff. These assumptions are clearly subject to

changes in passenger demand and airport planning but reflect the current best estimate. The assumptions made were:

- o 50 percent of the lot will be used by employees of which 40 percent will use the Transporter in the peak hour;

  Maximum system demand for employees will, therefore, be 1,414 x 50% x 40%, or 280 passengers per hour;

- o 50 percent of the lot will be used for long-term public parking. To calculate peak hour demand related to long-term public parking, we have used the same logic as in the calculation for the public parking lot, with an adjustment to the key parameters, as follows:

  - ratio of exit volumes to parking accumulation has been reduced from 0.26 to 0.20 to take account of reduction in peaking associated with long-term lot users;
  - passenger to vehicle ratios have been maintained at 1.5, which is considered conservative;
  - ridership has been conservatively estimated at 100 percent.

Peak demand associated with long-term users, therefore, is estimated at 1,414 x 50% x 0.20 x 1.5, or 212 passengers per hour.

- o The combined peak loading of employees and long-term lot has assumed a 70 percent overlap at the peak hour. The total combined peak loading on the Transporter from the multi-purpose parking lot has been estimated at 70 percent of the combined total, or 350 passengers per hour.

5.1.4 Combined System Demand

In the absence of data on coincidence of peak hours for public parking lot users, employees and long-term parking users, the conservative approach of simple addition of peak demand from each lot. This results in a peak hour demand of 900 passengers per hour on the outbound direction for both the parking lots.

5.2 SYSTEM CAPABILITY

5.2.1 Methodology

Four basic Transporter alignments for the Vancouver Airport were considered. With each of these alignments, performance can be affected by parameters, as follows: dwell time, maximum speed, acceleration/deceleration, passenger spaces and system configuration.

Two factors key to assessing a system are frequencey and capacity. These two parameters were plotted against speed and passenger spaces respectively for the four options.

Round trip time is calculated from the following:

$$RTT = TD + (2N-3) \times SD + \frac{(4(N-2) + 4)V}{a} + \frac{2d - (4(N-2+4))V^2/2a}{V}$$

Where TD = terminal dwell (sec)
N = number of stations
SD = intermediate station dwell (sec)
V = maximum speed (m/s)
a = nominal acceleration (m/s^2)
d = system length (m)

The first two terms sum the time spent in stations. The third term calculates the time spent in the accelerations and deceleration sections. The final term evaluate the time spent at cruise velocity.

Capacity is calculated with the following formula:

$C = 3600 \times PS/RTT$

where PS = passenger spaces

5.2.2 Results of Calculation

The first option (Figure 6) is a system that operates from the east side of the main terminal and runs through the main parking lot (east-west), making three station stops before continuing on to the remote parking lot, where two stations are serviced. One scenario is a simple shuttle that operates over the entire length. A second configuration is a shuttle that divides into two sections, such that one portion continue to the remote lot, while the other section runs back to the main terminal and completes a second cycle, then awaits the return of the remote lot shuttle to begin the cycle again. All other options are simple shuttles.

For the various options, the round trip time to service the remote parking lot lies between 11 and 13 minutes, using a conservative maximum speed of 5 m/s.

A service built for the main parking facility only would result in round trip times of five minutes. This level of service provides more frequent service than the present shuttle bus, but has fewer station locations.

In Table 4, the various Transporter service options are presented. The required capacities are unlikely to be necessary before the year 2,000, as is discussed further in Section 7.1. To provide a simple shuttle serving to both parking lots is inefficient and would require excessive station lengths. The simplest near term solution is a divided shuttle, whereby trains departing the main terminal station would divide at Station 4, with part of the train only continuing to the multipurpose lot. Service frequency would be doubled for the public lot relative to the multipurpose lot. In the long term, installation of a bypass track between Stations 2 and 3 would offer improved frequency and require less vehicles.

Route Option	Service Provided		Required Capacity PPHPD*	Round Trip Time Minutes	Passenger Spaces Required	Number of 16 Passenger Vehicles
4	Public Parking Lot only Simple Shuttle		550	5.1	48	3
2 or 3	Multipurpose Parking Lot only Simple Shuttle		350	11.0	64	4
1	Both Parking Lots Simple Shuttle		900	12.8	192	12
1	Both Parking Lots	Public Lot	550	6.4	60	
	Divided Shuttle	+ Multi-Purpose Lot	350	12.8	64	8
1 Modified	Both Parking Lots	Public Lot	550	5.1	48	
	Two Shuttles and Bypass Track	+ Multi-Purpose Lot	350	11.0	+ 64	7**

Notes: * Ultimate Capacity Approximate Year 2000
** Only 6 Vehicles if Crush Capacity Allowed For Multipurpose Lot

TABLE 4: COMPARISON OF TRANSPORTER SERVICE OPTIONS

5.3 SYSTEM SELECTION

5.3.1 Route Option

(i) Recommendation

Although the original intent of the study was to only investigate alternative routes between the multi-purpose lot and the terminal, it was evident that two separate transportation systems would be required, unless a system could be developed which would serve both the multi-purpose and public parking lots. Option 1 is the only route which achieves this and, for this reason, it is recommended. An additional factor in this decision was the impact of future terminal expansion to the north and east of the existing terminal. This would rule out Options 2 and 3 or at least unfavourably impact costs. The option of splitting the train from four vehicles into two smaller two vehicle trains is also recommended.

(ii) Description of Recommended Route

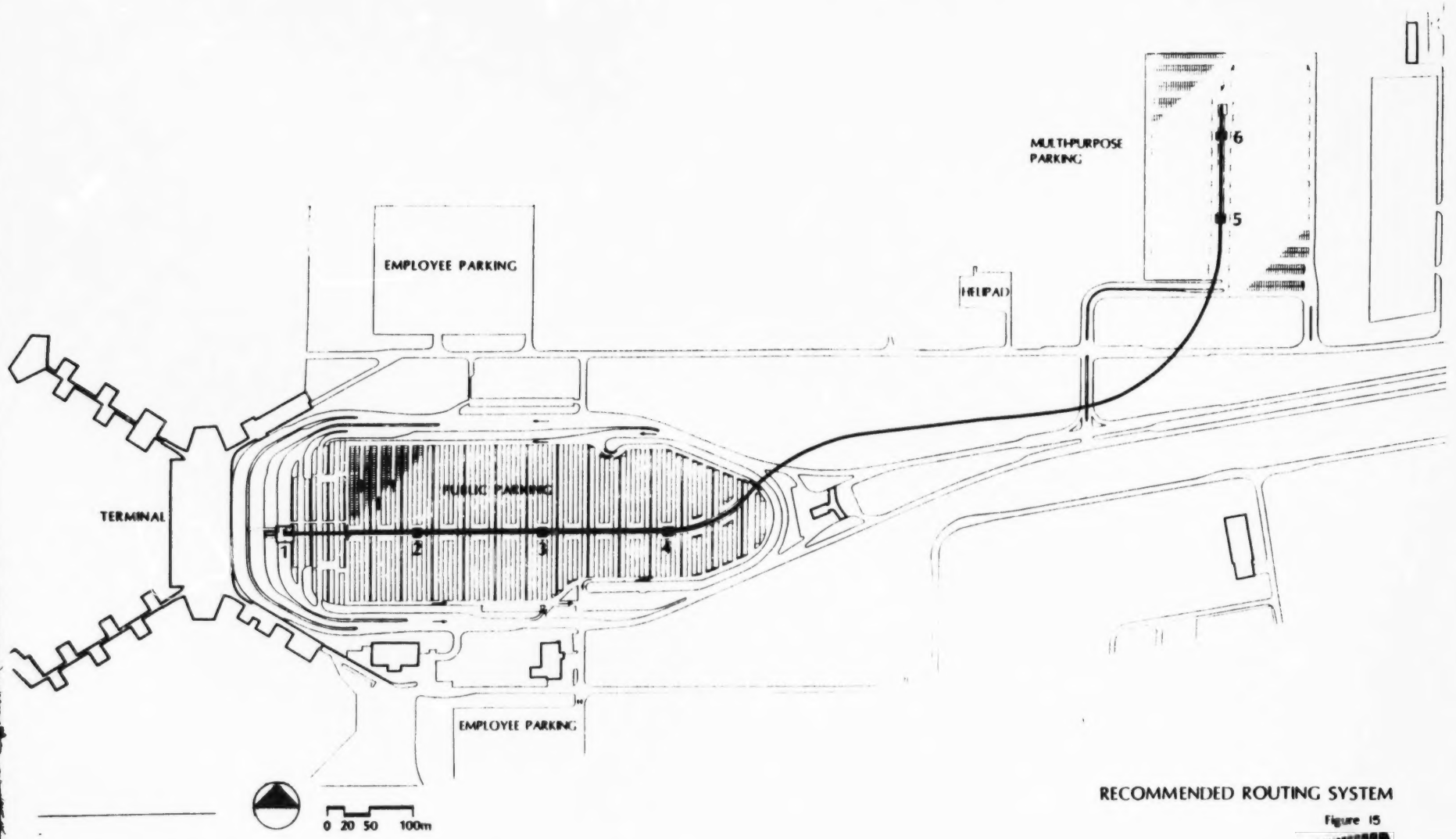
Route Option 1, as illustrated in Figure 15, is a development of the initial diagramatic representation illustrated previously in Figure 6. The route consists of 960 m of elevated guideway and 440 m of on-grade guideway, commencing with a Terminal Station and serving three stations in the public carpark and two stations in the multi-purpose carpark - all as previously illustrated in Figure 6.

The only modifications to the earlier layout are an offset of 12.5 m to the south of the centre line of the public carpark, influenced by the terminal station layout; and the introduction of a double-curve as the guideway leaves the public carpark, in order to minimize guideway spanning requirements across the terminal approach road.

Between the Terminal Station and Station 2, the guideway is elevated, initially running level, and then declining at 5%. East of Station 4, the guideway inclines at 4% to cross the terminal approach road and follows two gentle curves of approximately 200 m in radius. The guideway remains elevated and straight, following a route to the south of the CP Air Service Road, before turning north at a radius of 200 m and declining at 6% to Station 5 in the multi-purpose parking lot. An on-grade straight section of 100 m terminates the route at Station 6. The maintenance facility for the system is located immediately to the north of this station.

5.3.2 Transporter Equipment

The proposed vehicle would consist of a structurally stiff platform, reinforced longitudinally by the reaction rail assembly, with a non-structural passenger carrying shell. The vehicle would carry, as a design load, six seated and 10 standing passengers and be provided with luggage racks as shown in Figure 16. Empty



RECOMMENDED ROUTING SYSTEM

Figure 15

weight would be 1000 kg and, at crush load of 23 passengers, a weight of 2725 kg would result. Suspension would be via four articulated shoes of 1.8 m in length. Coupling of vehicles in trains up to four units in length would be via couplings mounted on the reaction rail. Initially, four vehicles and a spare would be required.

A total of 553 identical linear motors are employed, mounted at 2 m spacings in the stations, grades and curves, and at 4 m spacings in straight and level cruise sections. Each motor would be designed for a nominal stall thrust of 2000 N at an airgap of 10 mm. Magnetic proximity sensors would be used for vehicle position sensing. Each LIM would have an individual microprocessor-controlled, solid state switch/voltage controller. LIM module status would be conveyed to local area controllers at each station and, via multiplex link, to the main supervisory controller.

The air system would be a duplicated rotary-screw compressor feeding nominal 15 m sections via a duplicated network of feed pipes and solenoid valves. The entire track would be supplied via either system in case of planned maintenance or breakdown.

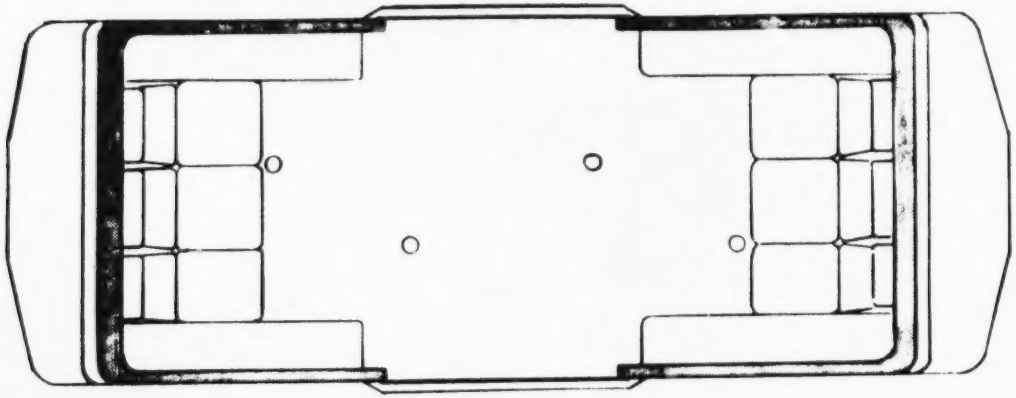
A number of low cost, elevated guideway designs were studied, all with a nominal span of 25 m between supports. The concrete inverted-Y section illustrated in Figure 17 is preferred on grounds of aesthetics and low cost. Vehicle retention and track contamination could be entirely avoided by use of a guideway cover of acrylic panels, but at some cost. This would ensure complete reliability in all weather, but would impose severe wind loads on the guideway. An alternative is the combined vehicle retention and rail protection scheme shown in Figure 17, which would prevent the majority of precipitation and contamination from reaching the tracks. It consists of a C-shaped cover with a gap-seal of bristle brushes, through which the vehicle shoe carrier passes.

5.3.3 Terminal Station

(i) Recommendations

In order to arrive at a recommended concept for the station, comparisons were made with the levels of service resulting from existing and potential methods of transporting passengers and public between parking and the terminal. These include:

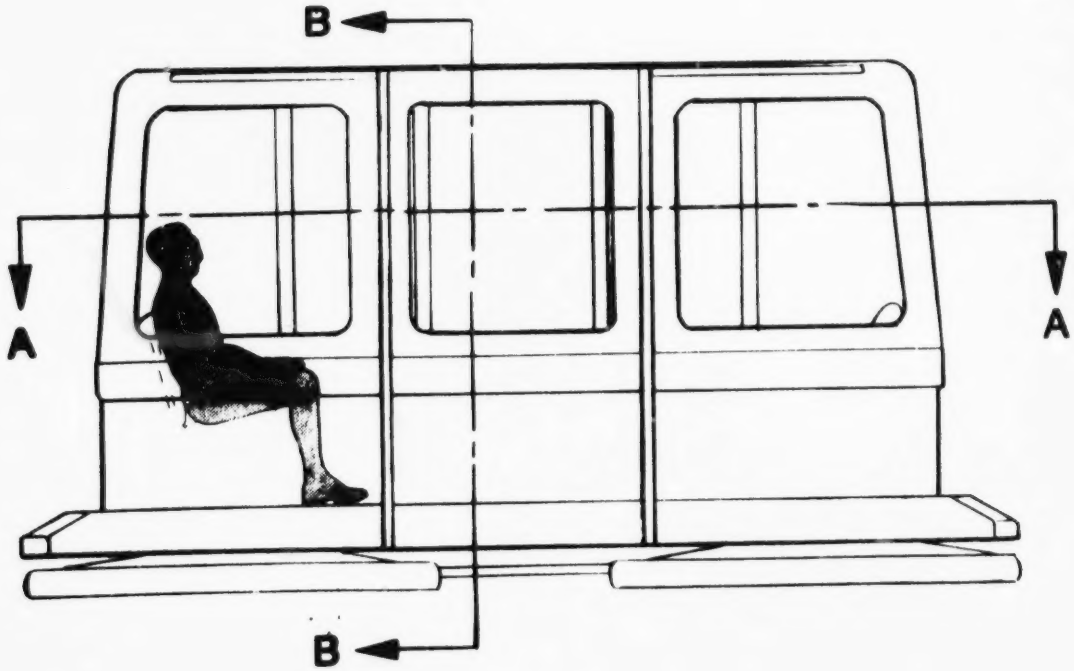
- the existing shuttle bus system;
- typical linkages that could be expected between a parking garage and the terminal.

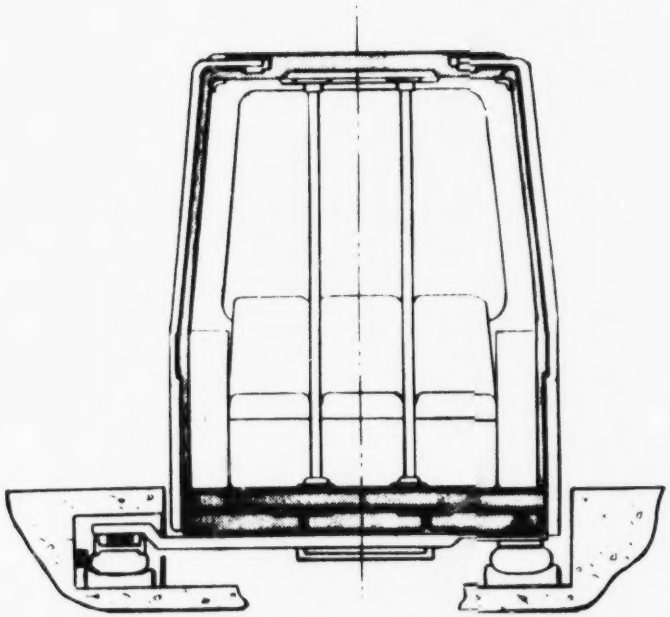


SECTION A-A

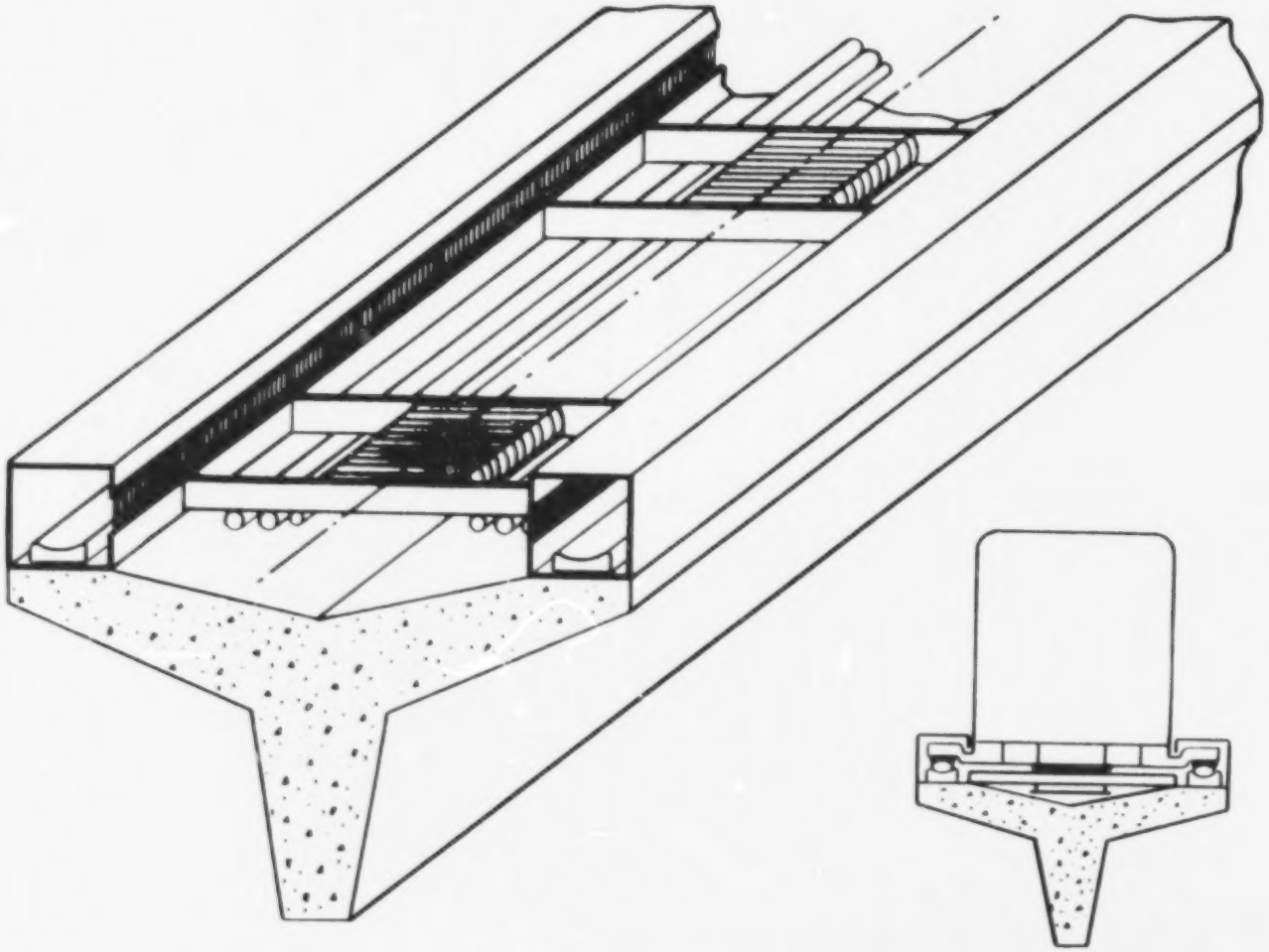
UTDC VEHICLE DESIGN

Figure 16





SECTION B-B



TYPICAL GUIDEWAY CROSS-SECTION

Figure 17

Criteria considered in these comparisons included:

- o walking distances, particularly for passengers with bags;
- o ease of access from all levels of the terminal;
- o orientation, i.e., location of station and comprehension of its purpose, relative to main passenger flows;
- o impact on the existing terminal; and
- o impact on the guideway, including operational and equipment selection.

During initial work on the project which was undertaken in Vancouver, Alternative A seemed a logical choice for a station concept because it provide an interface with the terminal, similar to that of the existing shuttle bus. It does not have a major physical impact on the existing terminal, and it could be integrated with a future planned parking garage in the long term.

Walking distances for passengers with bags, particularly to Level 3, in conjunction with the requirements to cross roads at Levels 2 and 3, are equivalent to current shuttle bus operations.

An improved shuttle bus system with drop-off/pick-up at all three levels, would resolve the walking distance and road crossing disadvantages. The purpose of investigating Alternatives B, C and D was to determine if a practical location could be found for the station which would significantly reduce walking distances.

Although the alternatives achieve the objective of shortening walking distances, this is done at the expense of physical impact on the existing building (i.e., new independent structures for station and guideway) and operational impact on terminal systems (i.e., existing escalators and new elevators). In the case of Alternatives C and D, the structural impact would be significant from the viewpoints of cost, inconvenience during the construction, and impact on existing space on all three levels resulting from new structured and required earthquake bracing. Alternative B results in awkward and indirect access routes from the terminal to the station and is not recommended. Alternatives C and D are totally dependent upon the existing escalator system and proposed new elevators for access to the station.

All alternatives require a steeper incline on the guideway (between the Terminal Station and Station 2) than the nominal 4% initially used. Station Alternatives A and B require 5%, this being determined more by height requirements for recreational vehicle circulating in the public parking lot than by the height of the station platform. in the case of Alternatives C and D, however, the resulting height of the station platform requires an incline of approximately 7%, which would have an adverse impact on Transporter equipment selections.

As the result of the foregoing comparisons, Alternative A is confirmed as the most practical concept for the station and is recommended for further development.

(ii) Description of Recommended Concept (Figures 18, 19 and 20)

The recommended concept is a further development of the diagramatic alternative previously illustrated in Figure 9 and described in Section 4.2.4.

The key element in the design is the station platform which acts as an interface between the Transporter system and the Terminal. The platform is located directly above the Level 1 roadway, immediatly to the south of the centre line of the terminal and the public parking. The floor of the platform is at an elevation of 5.9 m (19' 4") above the roadway, this height being largely determined by a slope of 1:20 on the bridge link to the Level 3 roadway. This slope is the preferred maximum gradient for disabled access.

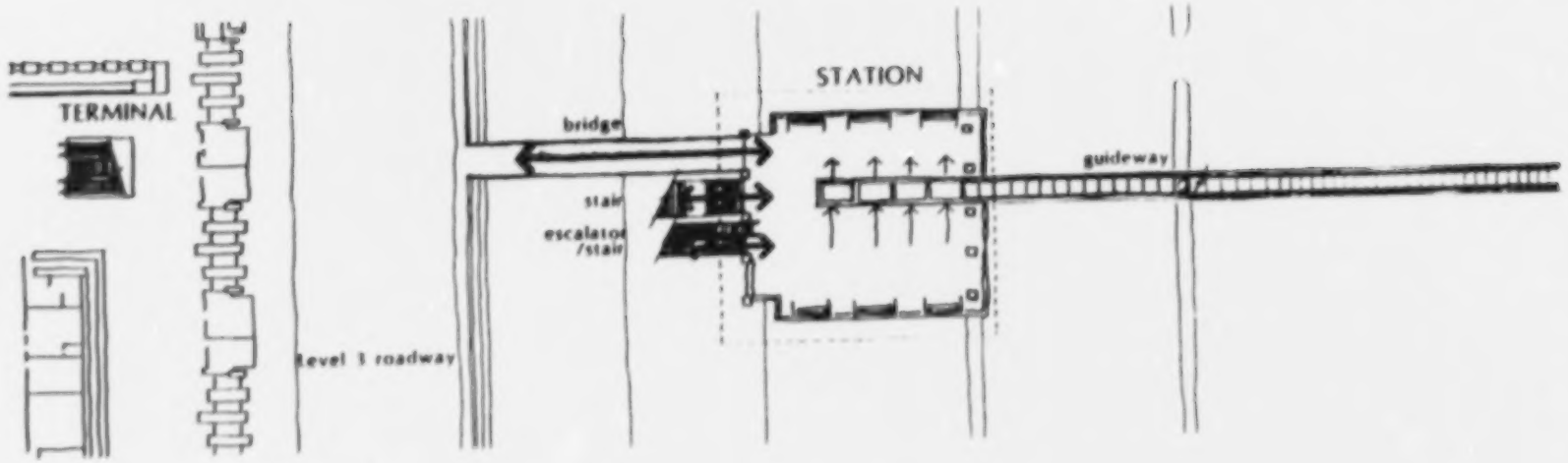
The height of the platform does not impact upon the incline of the guideway which, at 5%, is determined by the location of Station #2 relative to the westerly north/south vehicle circulation route in the parking lot.

The overall dimension of the platform is 24 m x 24 m (80' x 80'). The guideway, with its four Transporter vehicles, divides the platform vertically into segments which reflect minimal accumulation of arriving public and passengers (with bags and/or carts)generated by the peak demand on the system. The deplaning platform will accommodate approximately 100 people with bags and carts at 2.3 m^2/person. Although the station is basically open at the sides, glazed screens (2 m high) are provided for wind protection.

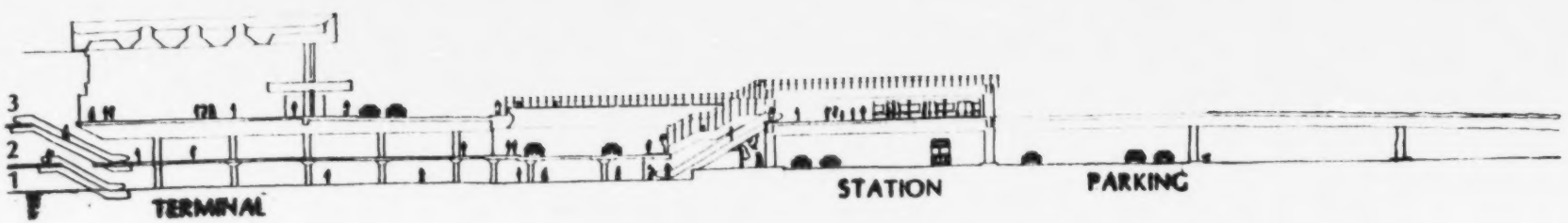
The connecting links to the three levels of the terminal are grouped together on the west face of the platform circulation area, allowing a simple signage system which will be easily understood by users.

The ramped bridge to Level 3 is covered as far as the raodway. It will be used primarily by International and Domestic enplaning passenger and related well-wishers,by enplaning/deplaning disabled passengers in all sectors, by disabled members of the public and also by baggage cart users.

A covered stair is provided from the platform to the east side of the Level 2 roadway. (Parallel escalators could be provided for improved levels of service.) This route will be used by enplaning Transborder and deplaning Domestic passenger and related well-wishes and greeters. The bridge connection to Level 3 above provides undercover protection for people crossing the Level 2 roadway.



LEVEL 3 PLAN



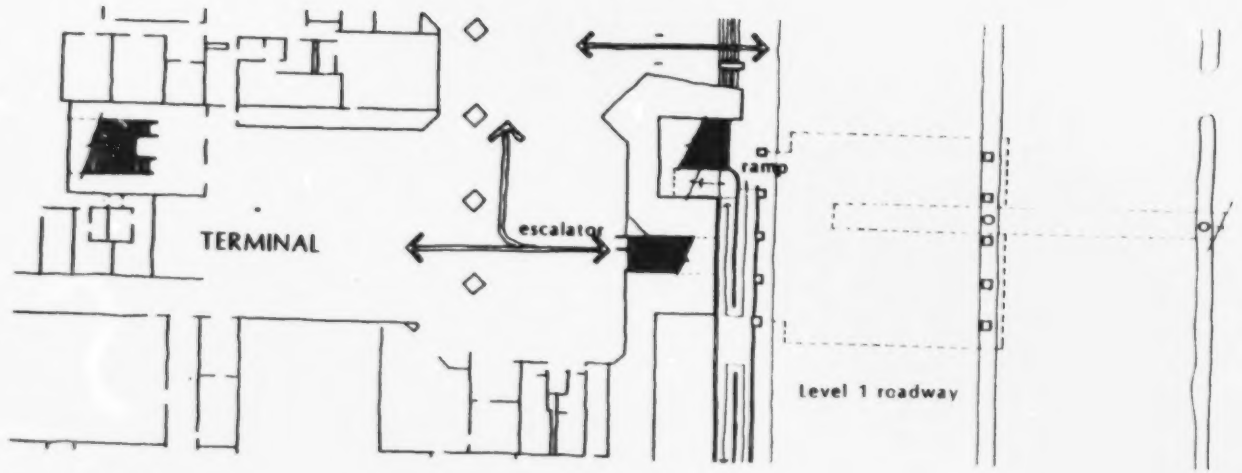
SECTION

0 10 25m

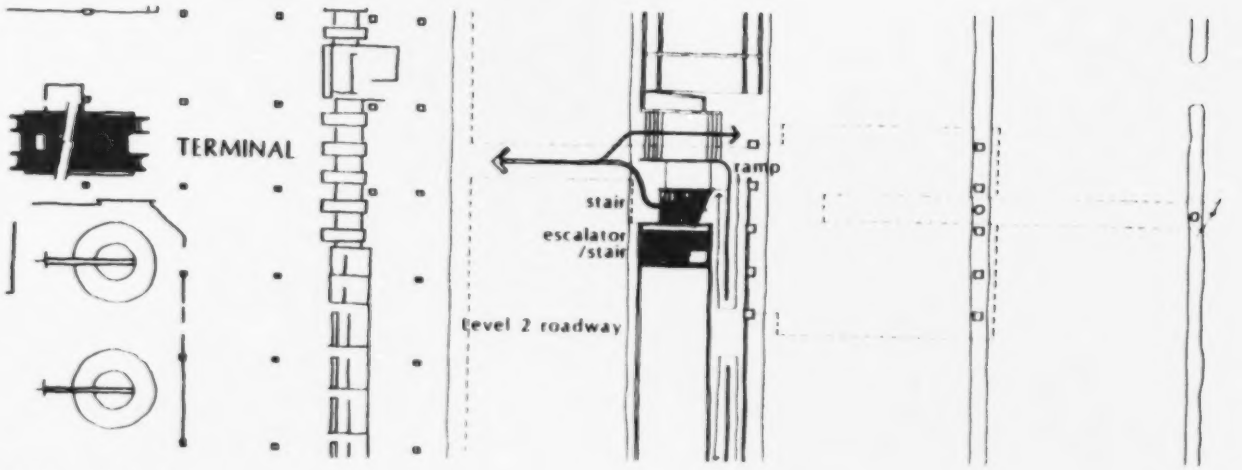
RECOMMENDED TERMINAL STATION

Figure 18

UTDC



LEVEL 1 PLAN



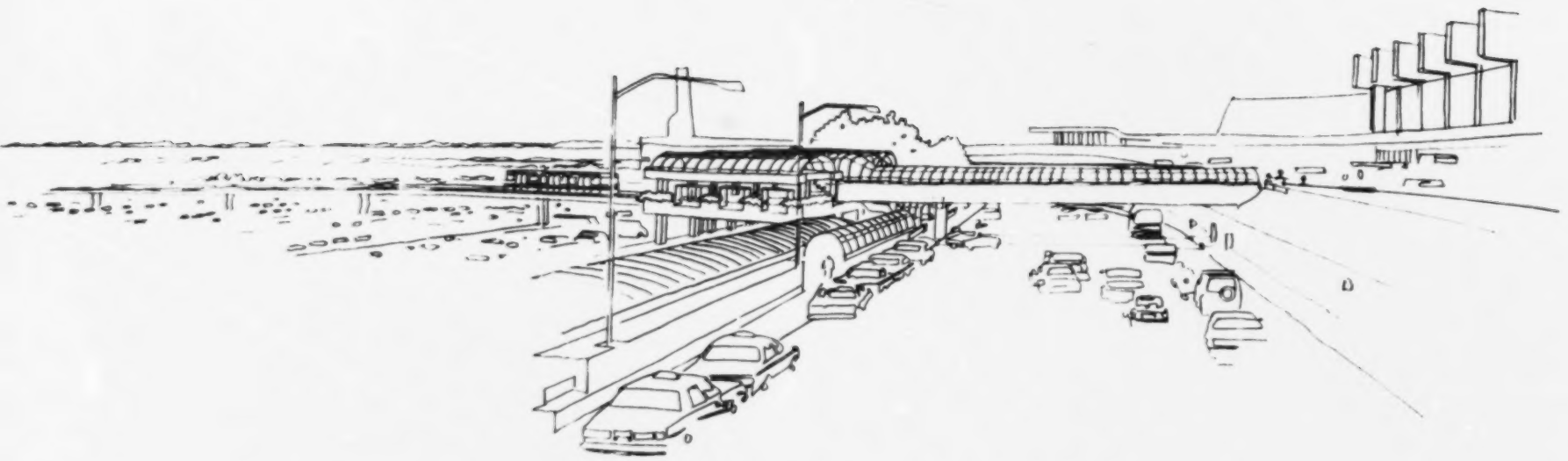
LEVEL 2 PLAN

0 10 25m

RECOMMENDED TERMINAL STATION

Figure 19

UTDC



VIEW FROM THE NORTH

RECOMMENDED TERMINAL STATION

Figure 20

UTDC

The existing central stair between the Level 2 and 1 roadways remains, and the general configuration at Level 2 will allow the new ramps recently proposed between thee Levels to be implemented by Transport Canada.

A covered stair and parallel escalator provide a direct link from the platform to the Level 1 public concourse. This route will be used by deplaning International and Transborder passengers and related greeters.

A reinforced concrete structure is proposed for the station, with the colour and texture of finish to match the existing. In general, all materials, finishes and details proposed are to match the existing adjacent exit structure from the International arrivals area, including the use of tinted acrylic barrel vault roofs (over the station, bridge, stairs and escalator), and generous use of planters, in order to ensure compatibility of expression with the existing complex.

Impact on the existing terminal structure and systems include the requirement for independent structural supports for the bridge to Level 3; and modifications to the existing corridor between gridlines T and U (at 17 and 18) on Level 1, which also involves the rerouting of existing mechanical and electrical services.

5.3.4 Parking Lot Stations

Parking lot stations (both for the public and multi-purpose carparks) are located on either side of the guideway in the positions shown in Figure 15.

Three of these stations are proposed in the public parking lot:

- Station 2, which corresponds in location to existing Bus Station 6;
- Station 3, which is slightly to the east of existing Bus Stations 1 and 5; and
- Station 4, which is slightly to the east of existing Bus Station 3.

The remaining two stations are located in the multi-purpose lot and replace the existing three bus stations.

The stations would be simple in appearance with glazed walls and a flat roof. Their overall length would be +12 m (sufficient to cover the door openings of a four vehicle Transporter train), and their depth would be 5 m.

5.3.5 Parking Lot Reconfiguration

(i) Public Parking Lot

The layout for the public parking lot is illustrated in Figure 14. This layout (identified as B1) is based on scheme B, previously illustrated in Figure 16, developed to include raised transverse pedestrian walkways which connect alternate rows of parking to two walkways which run parallel to the guideway. As stated previously, in Section 4.3.2, this arrangement will enhance pedestrian movement between parking stalls and the Transporter Sections. With this layout, a total of 2380 parking spaces can be provided.

As previously described in Section 4.3.2, a control system (probably requiring CCTV) will need to be devised in order to ensure equalized utilization of the north and south portions of the lot.

(ii) Multi-Purpose Lot

Figure 15 illustrates the proposed reconfiguration of this lot to account for the central guideway location, two stations and Transporter maintenance facility. This layout results in a reduction of 80 spaces over the existing total of 1843. As was the case with the public parking lot, a suitable system of controls will need to be devised to ensure equalized utilization of the east and west sections of the lot.

6.0 SYSTEM COSTS

6.1 TRANSPORTER CAPITAL COST

Budgetary capital cost estimates have been prepared for vehicles, mechanical and electrical equipment, guideway, stations, service building, service equipment, engineering and management, which result in a total cost of $10,000,000 in October 1984 dollars. This includes only those elements of the terminal station which are attributable to the Transporter system.

6.2 PARKING LOT AND TERMINAL ACCESS IMPROVEMENTS

Similar budgetary cost estimates have been prepared for providing undercover, multilevel access for the handicapped and persons with baggage carts to the station and reconfiguring the parking lots in the optimum manner. This results in a capital cost of $2,000,000 in October 1984 dollars.

6.3 TRANSPORTER SYSTEM OPERATING COSTS

The recommended Transporter system is estimated to cost approximately $160,000 per year to operate, broken down in the following manner:

o	Maintenance Spares	$ 45,000
o	Power Consumption	$ 25,000
o	Labour	$ 90,000
	TOTAL	$160,000/year

Note that this does not include Fixed facility maintenance.

6.4 SHUTTLE BUS OPERATING COSTS

The existing shuttle bus service operates for a period from approximately 6:00 a.m. to 1:00 a.m. with two vehicles plus one spare on site. At many times during the day only one vehicle is circulating with a round trip time of approximately eight minutes and offering a capacity of approximately 150 PPHPD. This increases to 300 PPHPD with two buses and a decrease in waiting time to four minutes results, depending on curbside congestion. This existing service costs $200,000 annually. To service the far lot, additional buses would be required. For an estimated round trip of fifteen minutes to provide 350 PPHPD would need four or five additional small 20 passenger buses or, at lower operating cost, three conventional 35' buses. No RFP has been issued to determine the cost of such a service but, based on similar systems elsewhere and the existing service contract, this would cost in the range of $400,000 to $500,000, depending on equipment, level of service and nature of contract. If increased traffic in the public lot is considered, the shuttle bus system will eventually cost $800,000 annually to operate in October 1984 dollars. This estimate is sensitive to fuel costs and wage rates for the drivers. Larger conventional buses might require a more skilled, higher paid (possibly union), operator.

7.0 COMPARISON OF SHUTTLE BUS VS TRANSPORTER

7.1 PARKING DEMAND AT VIA

As previously stated in the report, we have not been able to gather sufficient hard data to make an assessment of the current and projected requirement for parking at Vancouver International Airport.

Typically, what is required is a survey carried out on a number of peak planning days, which would reflect passenger activity represented by the official nominal schedule. In this survey, parking accumulation would be measured, as would vehicular traffic volumes entering and exiting the parking facilities. By calculating the peak accumulations over representative days and relating those peak accumulations to peak planning day and peak planning hour enplaned plus deplaned passengers, ratios can be arrived at that can then be used to project future parking requirements.

At Toronto's Terminal 2, an equation used recently to project future parking demand was devised as follows:

No. of short-term parking spaces required = 0.17 x (Planning peak hour enplaned + deplaned passengers)

No. of long-term parking = 0.09 x (Planning peak day enplaned + deplaned passengers)

In Section 5.1, we have made observations on the similarities between VIA and PIA-T2 in terms of peaking characteristics and sector splits. This was deemed appropriate in the context of transposing data on vehicular activity related to parking accumulations in the parking lot during peak periods. We cannot, however, transpose parking demand calculations from one airport to another for a number of reasons, the most important being:

- differences in ground travel time to each airport, which will, in all probability, affect modal splits;
- differences in pricing strategies for parking at each airport; and
- differences in levels of service provided for parkers at each airport.

Having said this, it is still interesting to apply the PIA-T2 equation to VIA to hypothetically predict what parking demand there might be if, in fact, the differences noted above were not substantial. The calculations associated with this exercise are

tabulated in Table 5, and the resulting demand curve is plotted in Figure 21. Also on this Figure, we have plotted the capacity of the existing public parking lot (2,190 spaces) and the combined capacity of public parking and 50% of the capacity of the multi-purpose parking lot.

YEAR	SHORT-TERM		LONG-TERM		TOTAL
	PPH(E+D)	X 0.17	PPD(E+D)	X 0.09	
1976	1,291	219	16,706	1,504	1,723
1980	1,800	306	23,350	2,102	2,408
1986	2,020	343	26,200	2,358	2,701
1991	2,470	420	33,000	2,970	3,390
1996	2,800	476	38,000	3,420	3,896
2,001	3,200	544	44,000	3,960	4,504

TABLE 5: CALCULATION OF THEORETICAL VIA PARKING REQUIREMENTS BASED ON PIA TERMINAL 2 PARAMETERS (CATA DATA)

This hypothetical demand curve would indicate that in 1984 the required capacity for planning peak day would be 2,610 spaces,or 420 more than the capacity supplied at the public lot. As stated previously, we do not have data on actual peak accumulations on the peak planning day at Vancouver. Discussion with VIA personnel have indicated, however, that the lot rarely has been more than 75 percent full over the past summer. This would mean that for the same number of planning peak day enplaned plus deplaned passengers, 40 percent less demand for parking is exhibited at Vancouver than at Toronto's Terminal 2.

If we assume that this trend were continued which, in turn, contains the inherent assumption that levels of service were not improved at Vancouver, a second curve could be plotted to indicate what actual parking demand may be expected at Vancouver over the next 20 years. This more realistic curve is also plotted on Figure 21.

In terms of projected demand for parking at Vancouver, even this curve may overstate demand, based on current level of service standards. We make this statement based on ridership figures for the shuttle bus service supplied to us by airport staff at VIA. These figures show that, despite a steady increase in annual origin plus destination passengers of 53 percent between 1977 and 1982, shuttle bus ridership declined from 821,680 passengers in 1977 to 412,750 passengers in 1982, a decline of 50 percent. It is clear that improved data is required for firm predictions.

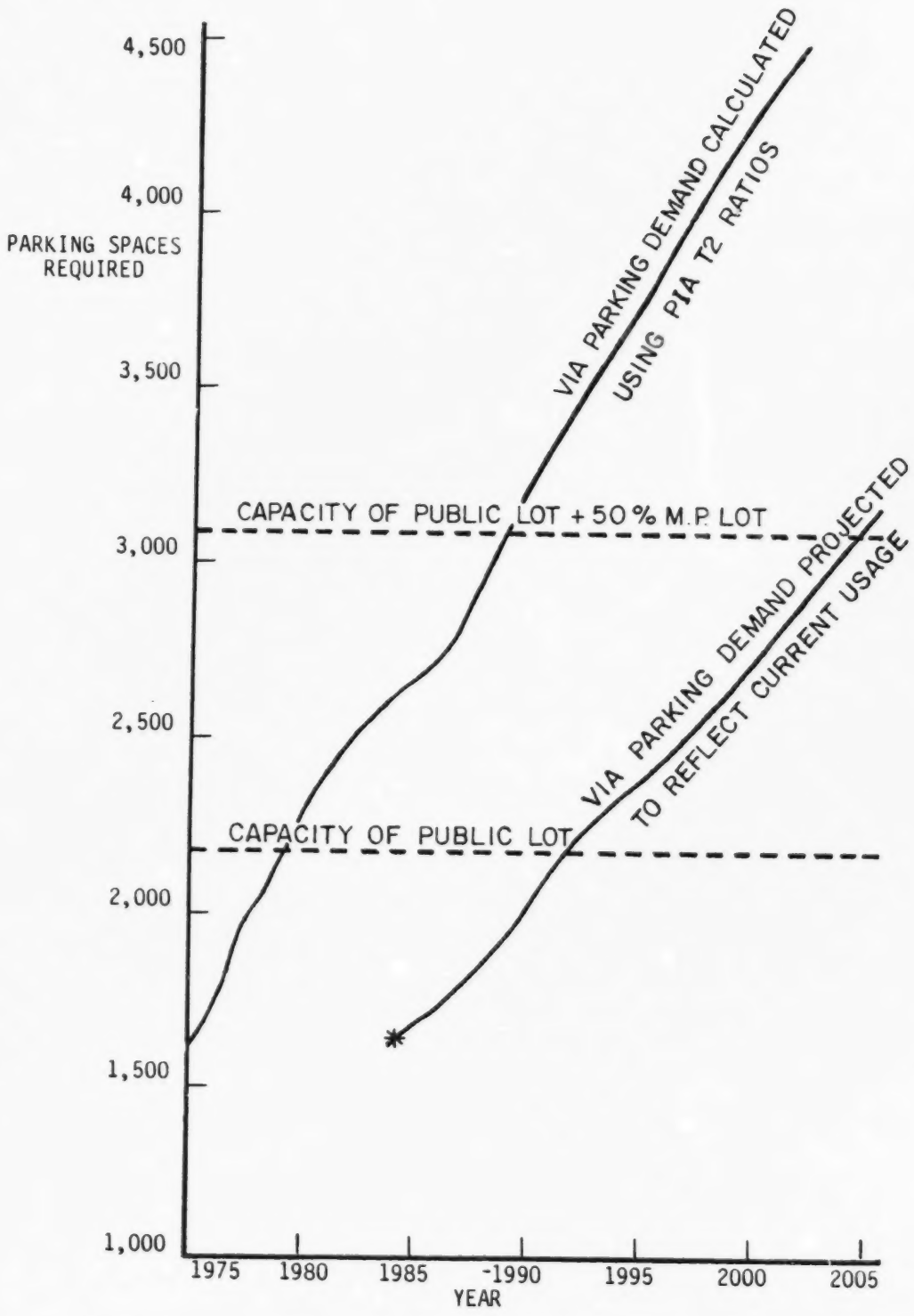


FIGURE 21: PARKING DEMANDS AT VANCOUVER INTERNATIONAL AIRPORT

7.2 INADEQUATE LEVELS OF SERVICE AND FOREGONE REVENUES

The envelope between the two curves plotted on Figure 21 could be considered to represent the elasticity of parking demand relative to the three parameters discussed previously, i.e.:

- o modal splits
- o pricing
- o levels of service.

Level of Service is the one parameter that is of most interest when considering a comparison between the shuttle bus service and a Transporter service at the main parking lot.

It may well be that even if similar levels of service were provided at Vancouver as at Terminal 2, i.e., a parking structure with direct links to the terminal building, we would still not experience the same level of demand as at Toronto because modal splits may be inherently different between the two cities. We assume that a decision to improve levels of service for the parking public at Vancouver would result in some increased demand for parking.

Closely linked to demand is revenue generated from the parking facilities. Parking revenues currently contribute approximately $4 million annually. If a parking structure were built at VIA, it is conceivable that 50 percent of the "latent" demand illustrated in Figure 21 would be realized.

Implementation of the Transporter system, although judged as a superior service to the existing shuttle bus system, would not result in the increased levels of demand that would probably be experienced through construction of a well-planned parking structure. It is also conceivable, however, that the introduction of a Transporter system would contribute half of the theoretical demand increase attributable to introduction of a parking structure.

At current levels, this would mean that an increased revenue potential of $660,000 annually may be available through introduction of the Transporter system.

7.3 TRANSPORTER SYSTEM BENEFITS

A review of this application study will show that a number of benefits will accrue to Vancouver International Airport if the Transporter could be installed as proposed. In summary, these are as follows:

- o Frequency of Service

  Transporter will serve the main parking lot every five minutes, regardless of demand on the system. This compares favourably to the shuttle bus. which has a headway range of

5.5 to 8 minutes. Similarly for the multi-purpose lot, Transporter would serve the lot every 11 minutes, as compared to an estimated 15 minutes for a shuttle bus.

- o Curb Congestion

  The current shuttle buses serve either level 1 or 2 at the terminal; a different bus serving each level. This causes considerable congestion, especially at level 2 where people will enter the terminal and then redistribute to levels 1 or 3 using the stair/escallator installations. The Transporter station has been designed to distribute people directly into their destined level. Congestion at level 2 is, therefore, mitigated.

- o Level of Service

  Fixed transit systems, such as Transporter, traditionally operate at close to 100% availability, thus ensuring a predictable and reliable level of service. This assured level of service, coupled together with its high visibility, gives users a level of confidence which will encourage its utilization. This, in turn, will have dramatic impact on the utilization of the parking lots.

- o Parking Revenue

  The level of service, including its frequency, should result in increased utilization of the parking lots and subsequently increased revenue for the airport. Historically, utilization of a surface parking lot is lower compared to available alternatives. Vancouver International Airport has additionally an unexplained decrease in cars, over the last five years, utilizing the parking lots. This may, in part, reflect the level of service that parkers perceive they get. If a driver believes he has to walk the full distance to the terminal, and that he will have to park in the back half of the lot, he may well elect to take a cab and obtain curb to curb service, and be willing to pay the premium. The additional annual revenue is estimated to be a maximum of $660,000 (See Section 7.4).

- o Operating Costs

  To operate the current bus system and extend this level of service to the multi-purpose lot would cost $400,000. To increase the frequency to match Transporter, a total of eight buses would be required and operating costs would be approximately $800,000.

  Transporter operating costs are estimated at less than $200,000 per year. Therefore, with current level of service, the operating saving would be $200,000. If bus frequency were increased and compared to Transporter, the saving would be $600,000.

- o Energy Issues

  The installation of Transporter will eliminate the need for a small bus fleet utilizing fossil fuel. The project supports, therefore, Transport Canada's "off-oil" policy.

- o Equitable Service

  Transporter is also designed to provide equitable service to the elderly and handicapped. The buses currently do not provide this and cannot achieve the level of service Transporter provides.

7.4 COMPARISON OF SYSTEMS ON A PRESENT VALUE BASIS

Present value calculations have been carried out to compare the two systems for the period 1987 to 2005 using two different projected economic scenarios and two passenger demand projections. These results are compared in Table 6 below. In cases where there is increased parking demand the Transporter shows approximately equal or reduced present values when compared to a shuttle bus system. In cases where parking demand remains at a constant (and current) proportion of passenger flow the shuttle bus system is less costly on a present value basis. Recent decisions by the Federal Government to increase parking fees at Airports will impact the trade-off in favour of Transporter.

Economic Scenario / Forecast Parking Demand	13% Borrowing 6% Inflation		9% Borrowing 5% Inflation	
	Transporter	Shuttle Bus	Transporter	Shuttle Bus
Increased 25% Based on "Level of Service"	4.5	4.5	3.4	5.9
Constant Proportion of Passenger Flow	11.7	4.5	12.1	5.9

TABLE 6: PRESENT VALUE CALCULATION RESULTS - MILLIONS OF DOLLARS

8.0 OTHER VANCOUVER APPLICATIONS

There are two potential applications in Vancouver that would use the same technology including:

- o Vehicle
- o LIM Module
- o Controls Software
- o Rail
- o Pneumatic System Components

The work carried out in this study has confirmed the feasibility of both of these applications from a technical point of view.

Each system is described below.

8.1 GRANVILLE ISLAND

This proposed system is a 420 m long straight line shuttle running on a guideway mounted below the Granville Bridge. It would connect a multi-level parking structure at the northeast end of the bridge with the Granville Island area to the southwest of the bridge mid-point. The guideway would have an approximately 4% grade and a simple station at each end. To gain access to the guideway at the Island end a structure containing an elevator would be required. A previous study of this application was carried out and was reviewed as part of the current work. The proposed installation is described in Attachment "A".

8.2 EXPO '86

A potential application is a 70 m simple straight line shuttle at a 5 to 6% grade linking the entrance to the EXPO '86 site to the ALRT station. Only the most arduous inclined part of the walkway (approx. 150 m overall) is paralleled by the Transporter System.

9.0 CONCLUSIONS AND RECOMMENDATIONS

The study had the objective of determining the feasibility of the application of a Transporter system to move people from the new multi-purpose parking lot to the main passenger terminal. It was concluded that:

- it is feasible to deploy Transporter technology for use at VIA;
- there are technical challenges, given the current status of development. The major ones are resisting wind loads and reducing contamination of the rail surface. A feasible scheme has been developed to meet these objectives;
- a number of route options are technically feasible, but the preferred option would also serve the main lot;
- a passenger carrying capacity that would meet demand until the 2005 timespan is feasible with near term technology for both parking lots;
- the application could be economically justified when compared to existing and upgraded shuttle bus services, depending on long-term parking demand and economic scenario chosen:
- overall Transporter system cost is in the range of $10,000,000 ±20%;
- annual operating cost for a service to both lots will be 1/3 to 1/4 of that needed for a shuttle bus service, representing eventually savings of approximately $600,000 annually;
- the application has other benefits such as better accessibility for the handicapped, off-oil transportation and continuing demonstration of advanced Canadian technology;
- similar conclusions are drawn for two other potential applications in Vancouver, namely, the Granville Bridge and Expo '86 applications described in this report.

On the basis of the work carried out and previous technical and marketing studies done by UTDC, it is concluded that Transporter technology does have an application in the Vancouver and other market places. As with any new system of this magnitude, forecasting cost and performance over many years has a certain element of risk. Although the prototype technologies used in the current system require productionization of design and further confirmation as to long term reliability, the contractor for this study concludes that the technologies could be deployed in the Vancouver operating environment studied.

It is recommended that:

- necessary technology productionization be stimulated as quickly as possible;
- Transport Canada review the possible alignments and operational requirement, as indicated in this report, and indicate its preference;
- typical transit system operating standards assumed in this report should be examined, particularly with regard to right of way requirements, when the system operates in the presence of pedestrians;
- up to date passenger and parking demand data be obtained at Vancouver International Airport;
- a flexible, relocatable Transporter system be developed to enable flexible long range response to changes in system demand.

10.0 REFERENCES

1) "Application of SailRail Technology to the Transit Industry" TP4766E prepared for Transport Canada by UTDC R&D, June 1983.

2) "Vancouver International Airport Master Plan" TP2375, December 1981.

3) "Handbook of Fundamentals", 1980, ASHRAE.

4) "Climatic Normals 1951-1980 - Vancouver International Airport B.C.", Environment Canada.

5) "Canadian Climate Normals, Volume 5, WIND", Environment Canada.

6) "Conceptual Design", UTDC R&D Ltd., 447-700-001.

Attachment "A"

Transporter

A proposal for improved access to Granville Island

CONTENTS

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TRANSPORTATION REQUIREMENTS FOR GRANVILLE ISLAND	3
THE TRANSPORTER — THE SOLUTION FOR GRANVILLE ISLAND	5
LIGHTWEIGHT, COMFORTABLE VEHICLE	6
GUIDEWAY	9
STATIONS	11
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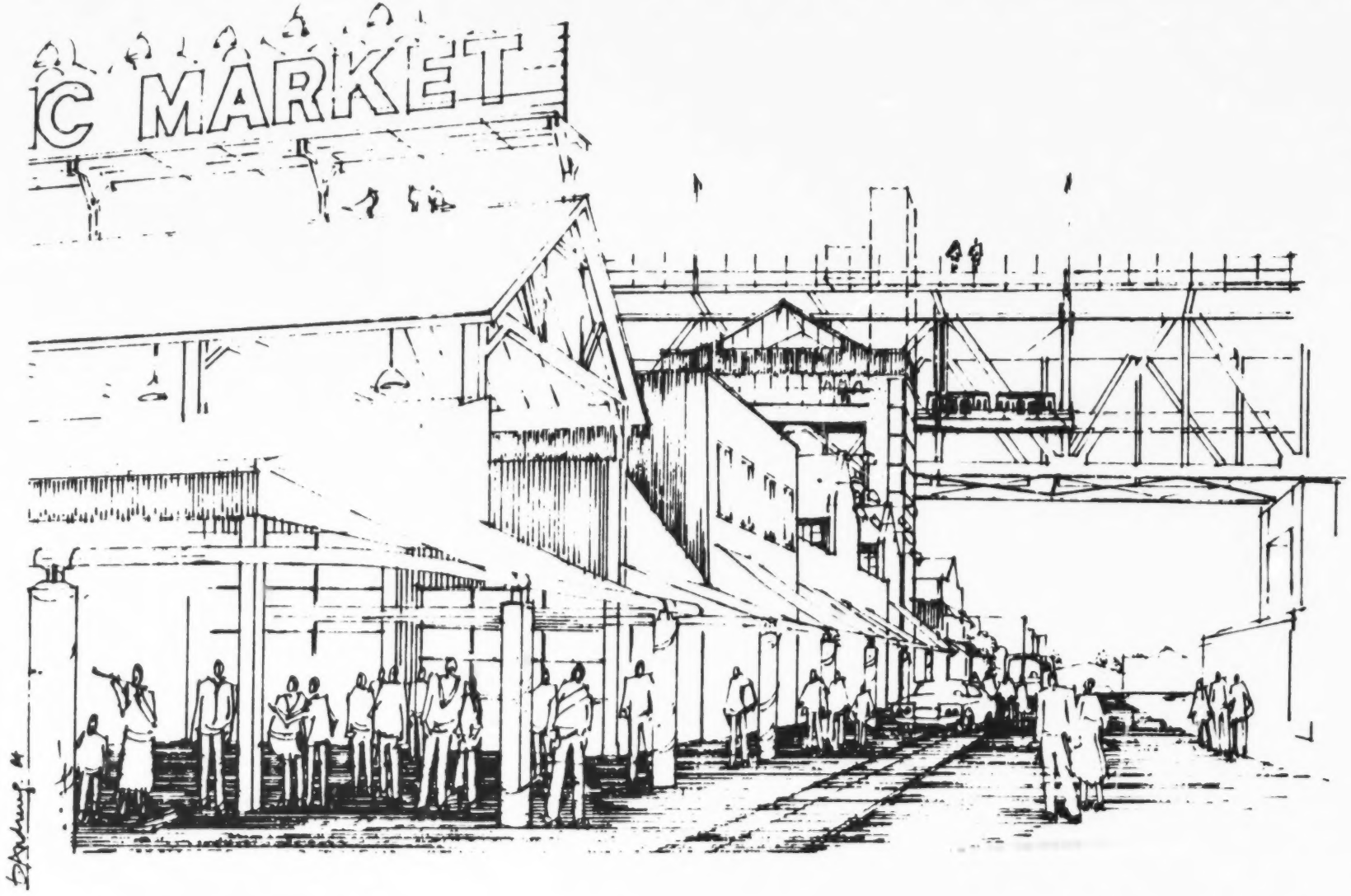
THE PROPOSED TEAM	15


C MARKET

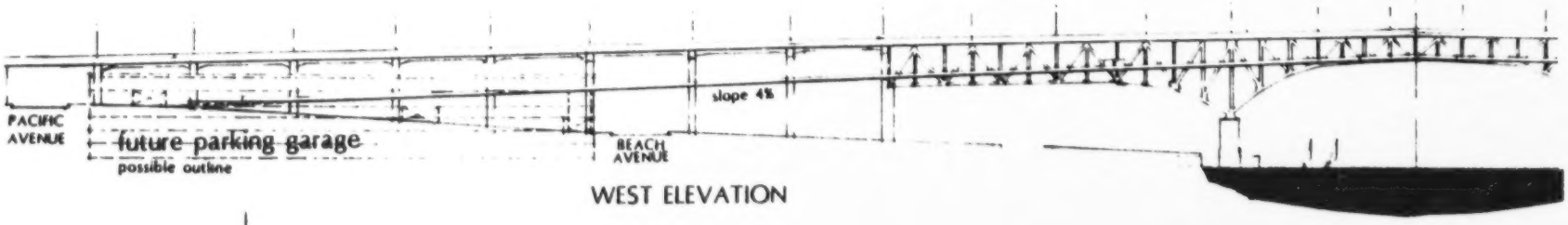
TRANSPORTATION REQUIREMENTS FOR GRANVILLE ISLAND

Once the heart of industrial activity in the False Creek Basin, Granville Island is now one of Vancouver's premier attractions. With a successful mix of recreational, commercial and cultural facilities, Granville Island today captures the flavour of its beginnings in a unique urban environment.

Currently there is no easy and convenient access to the island. In the south the island is linked to the mainland by a narrow causeway. Traffic on this route is often congested and only limited parking space is available on the island. An infrequent bus service provides only a modest quality service for non-automobile users. On the north the island is separated from downtown Vancouver and the densely populated West End by False Creek.

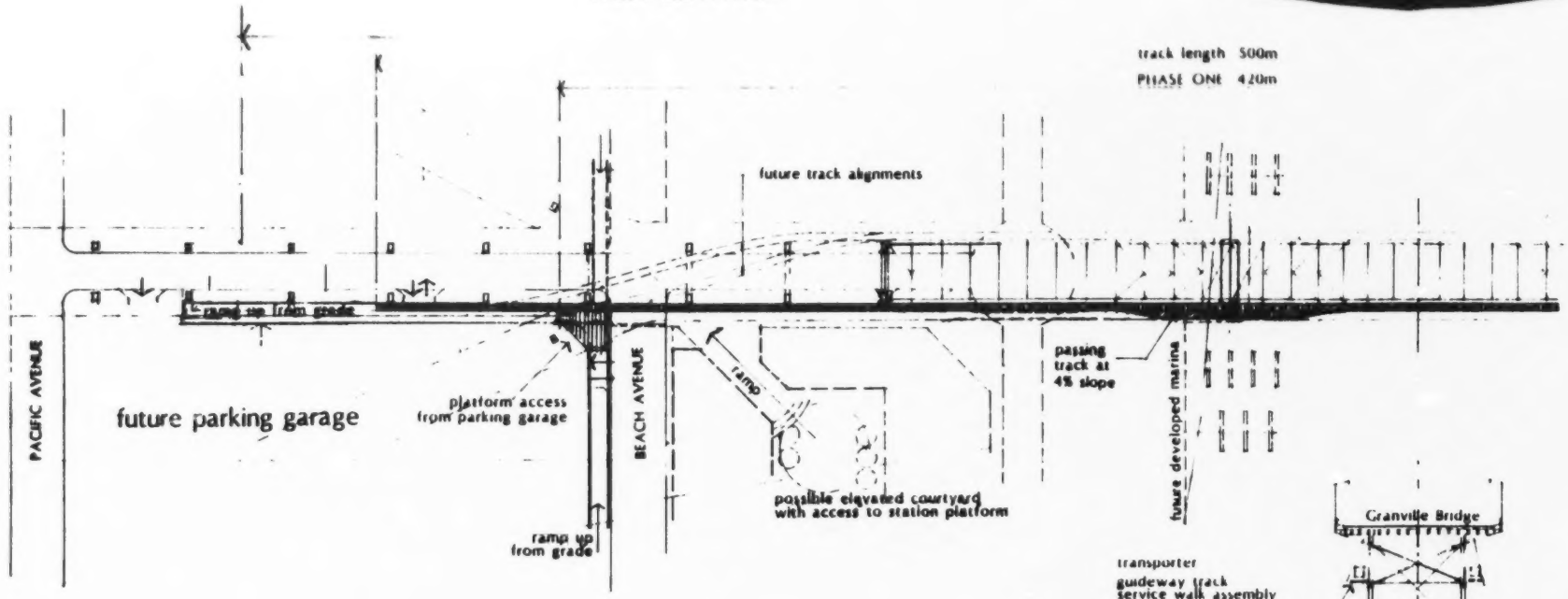
There is an immediate need for a new transportation system connecting Granville Island to the Downtown and West End. Furthermore, in the next few years, Expo'86 and BC Place will also be built on the north side of the creek, generating additional demand for a connection. An expedient, accessible and direct link would provide a tremendous benefit for people visiting or working on the island. Connected to a new parking garage being built by the city on the north side of the creek, a new link would also reduce automobile congestion and solve the island's parking problem.

A PROPOSAL FOR IMPROVED ACCESS TO GRANVILLE ISLAND



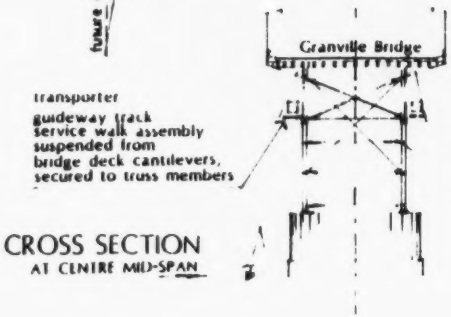
WEST ELEVATION

track length 500m
PHASE ONE 420m

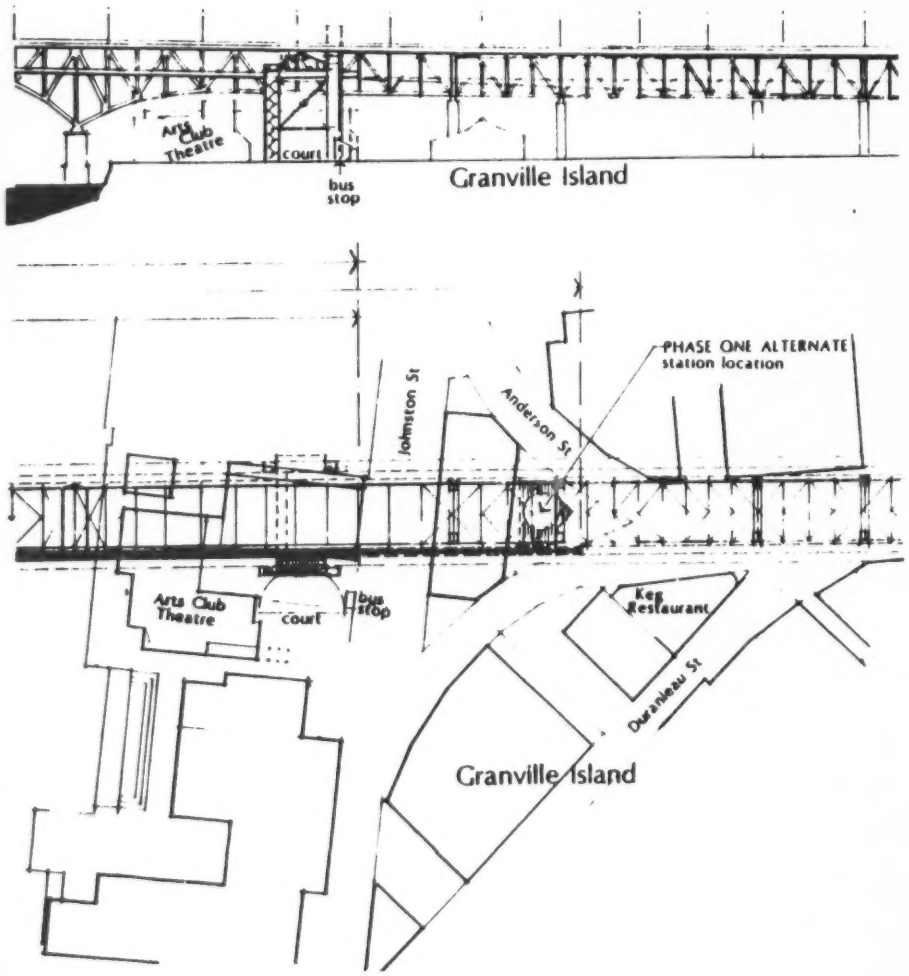


PHASE ONE
PHASE ONE ALTERNATE
FUTURE PHASE(S)

PLAN


Granville Bridge
transporter guideway track service walk assembly suspended from bridge deck cantilevers, secured to truss members

CROSS SECTION
AT CENTRE MID-SPAN



THE TRANSPORTER — THE SOLUTION FOR GRANVILLE ISLAND

The Transporter will provide a fast, direct and convenient transportation link between the downtown peninsula and Granville Island. The system proposed is a simple shuttle approximately 420 metres long.

A 32 passenger tram will run on a track suspended underneath the west side of the Granville Bridge. There will be a station at each end, one above Granville Island, and one between Pacific Avenue and Beach Avenue on the north side of False Creek. The vehicles will glide gently along at a speed of about 20 km/h, offering a scenic trip between the stations in just over 1.5 minutes.

The Transporter incorporates two unique Canadian technological innovations: low maintenance air bearing track with resilient runners on the vehicle, and track mounted linear induction motors (LIMs) with a vehicle mounted reaction plate. These features, combined with fully automatic lightweight vehicles, make this a reliable, comfortable and economical system, ideal for short point to point connections such as the Granville Island link.

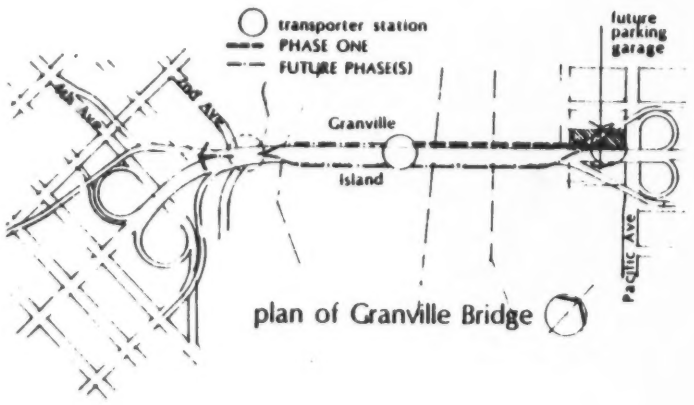
For the Granville Island application, the system will be capable of handling over 1,000 passengers per hour in continuous shuttle mode, with vehicles loaded at nominal capacity of 16 passengers and 120 second station dwells. The hourly capacity can be increased to approximately 1,400 passengers with vehicles loaded at crush capacity of 22 passengers. During hours of lower passenger demand the system can also be operated in a more call mode.

At the north end, the Transporter can run directly through the new parking garage now being built. The station will have grade level access directly to Pacific Avenue and into the parking garage. This entrance will be a two minute walk from the West Gate to Expo'86.

There are two alternative station locations on Granville Island, as illustrated on the previous page. Both allow for the potential development and integration of commercial functions in conjunction with the normal operation at each station. Either station would have elevator and stair connections to grade level, near to the Public Market.

In addition to the initial 420 metre track section, there is potential for the system to be extended south over Granville Island toward 4th Avenue.

The entire system will be accessible to the physically disabled.



plan of Granville Bridge

LIGHTWEIGHT, COMFORTABLE VEHICLE

The Transporter vehicle is comfortable, simple and practical in design. It has virtually no moving parts to break or wear out, and is electrically passive. The basic vehicle structure consists of a welded aluminum chassis which supports the aluminum and fibreglass carbody structure. Large windows on all sides of the vehicle provide visibility and views for seated and standing passengers. A single door is provided on one side of the vehicle. The door is opened manually from the station platform or from inside the vehicle, and closes automatically. A safety interlock prevents the vehicle from moving with an open door, and locks the door when the vehicle is moving.

There are six seats for elderly or disabled passengers, and stanchions are provided for standees.

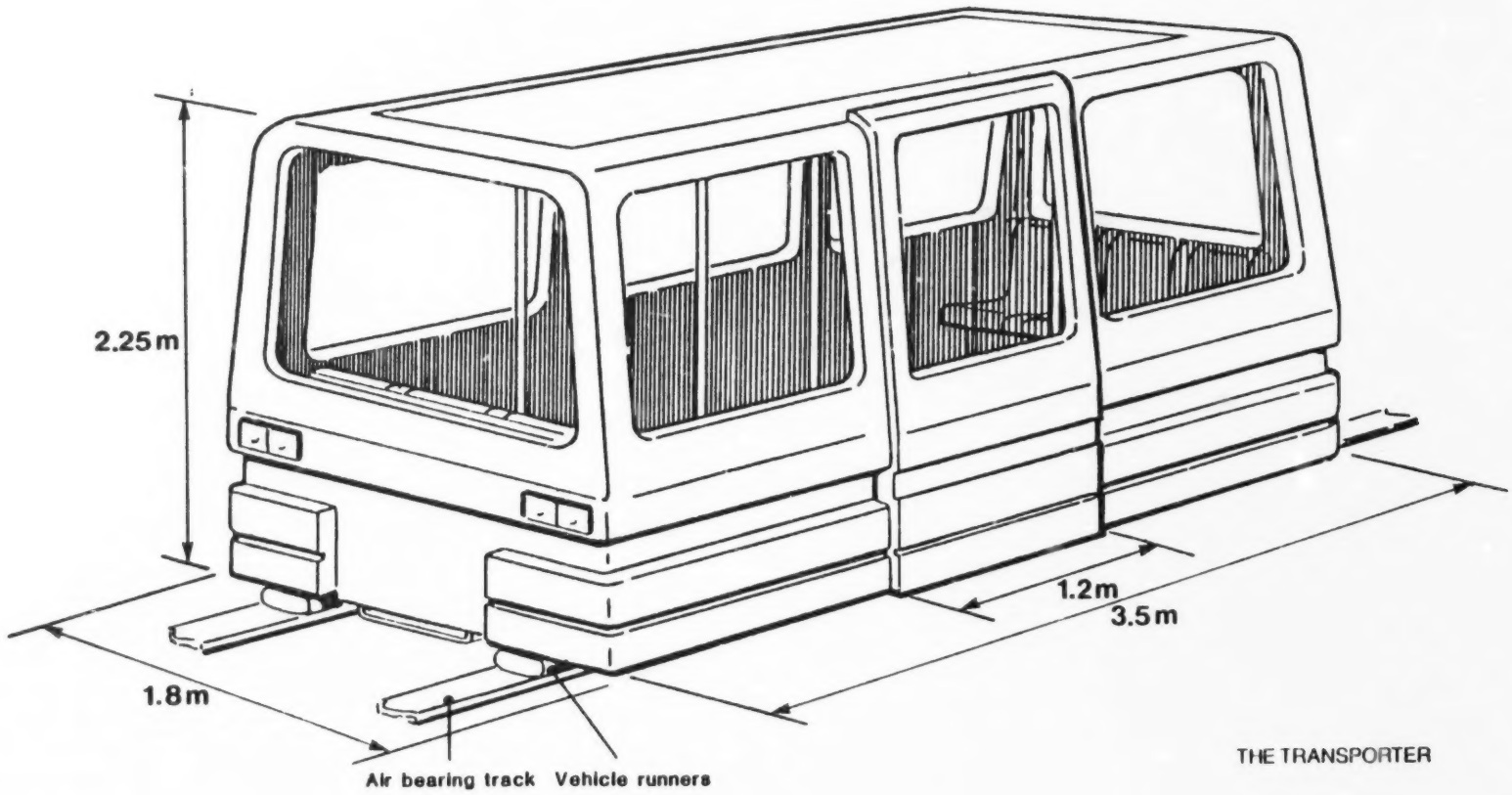
The main vehicle dimensions and weights are:

Length	3.5 m
Width	1.8 m
Height	2.25 m
Inside height	2.0
Vehicle door width	1.2 m
Vehicle weight with 16 passengers (6 seated and 10 standees at 4/m²)	2,200 kg
Crush loaded vehicle with 22 passengers	2,650 kg

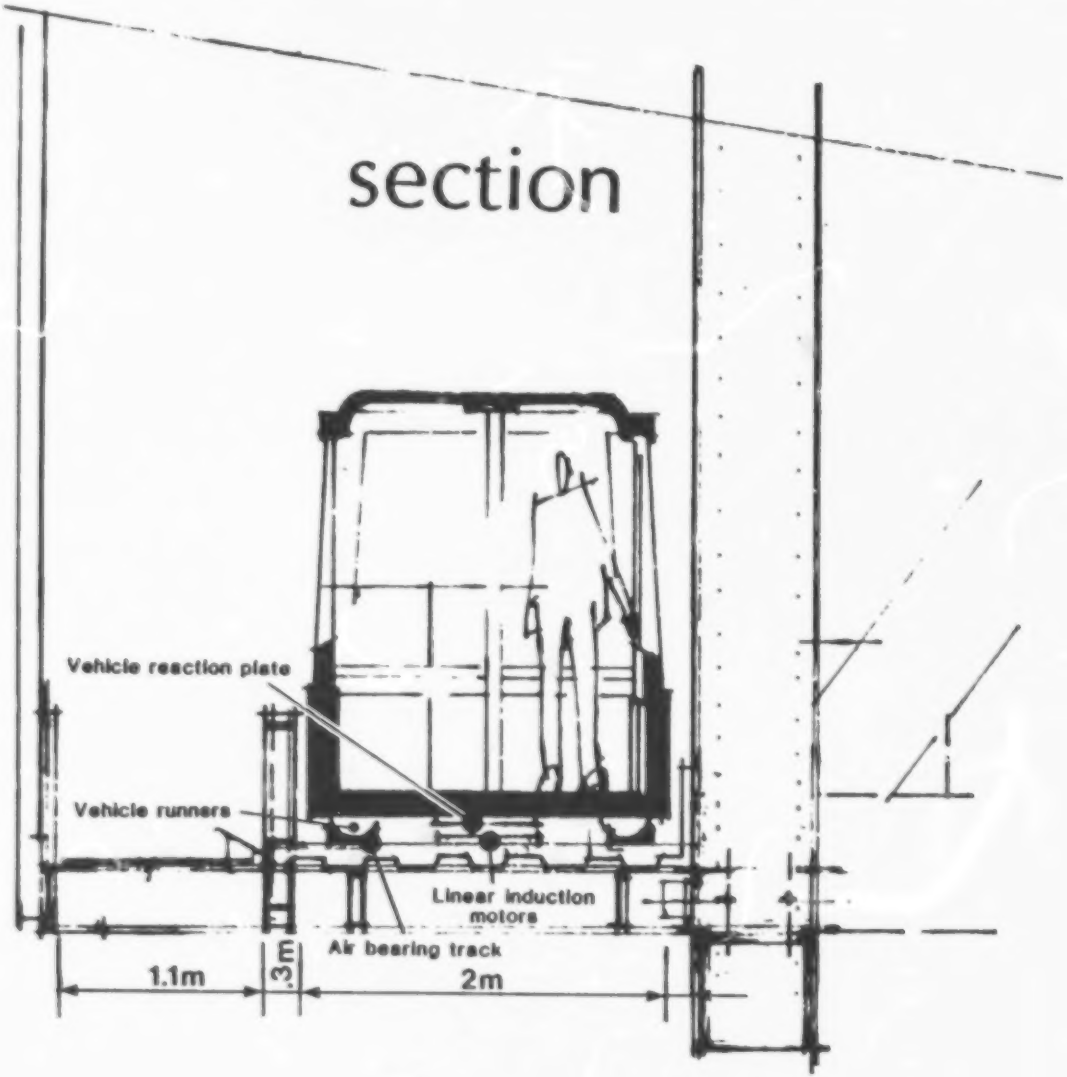
Key performance characteristics include:

Design speed	18 km/h
Maximum acceleration or deceleration	1.0 m/s²
Emergency deceleration	1.5 m/s²

Two standard vehicles will operate as a semi-permanently coupled train.



THE TRANSPORTER


section
Vehicle reaction plate
Vehicle runners
Linear induction motors
Air bearing track
1.1m
E
2m

GUIDEWAY

The Transporter system is ideally suited for installation under the cantilevered deck of the Granville Bridge. The vehicle dynamic and static loads are so low that no significant modifications of the bridge are required to support the new deck carrying the Transporter track.

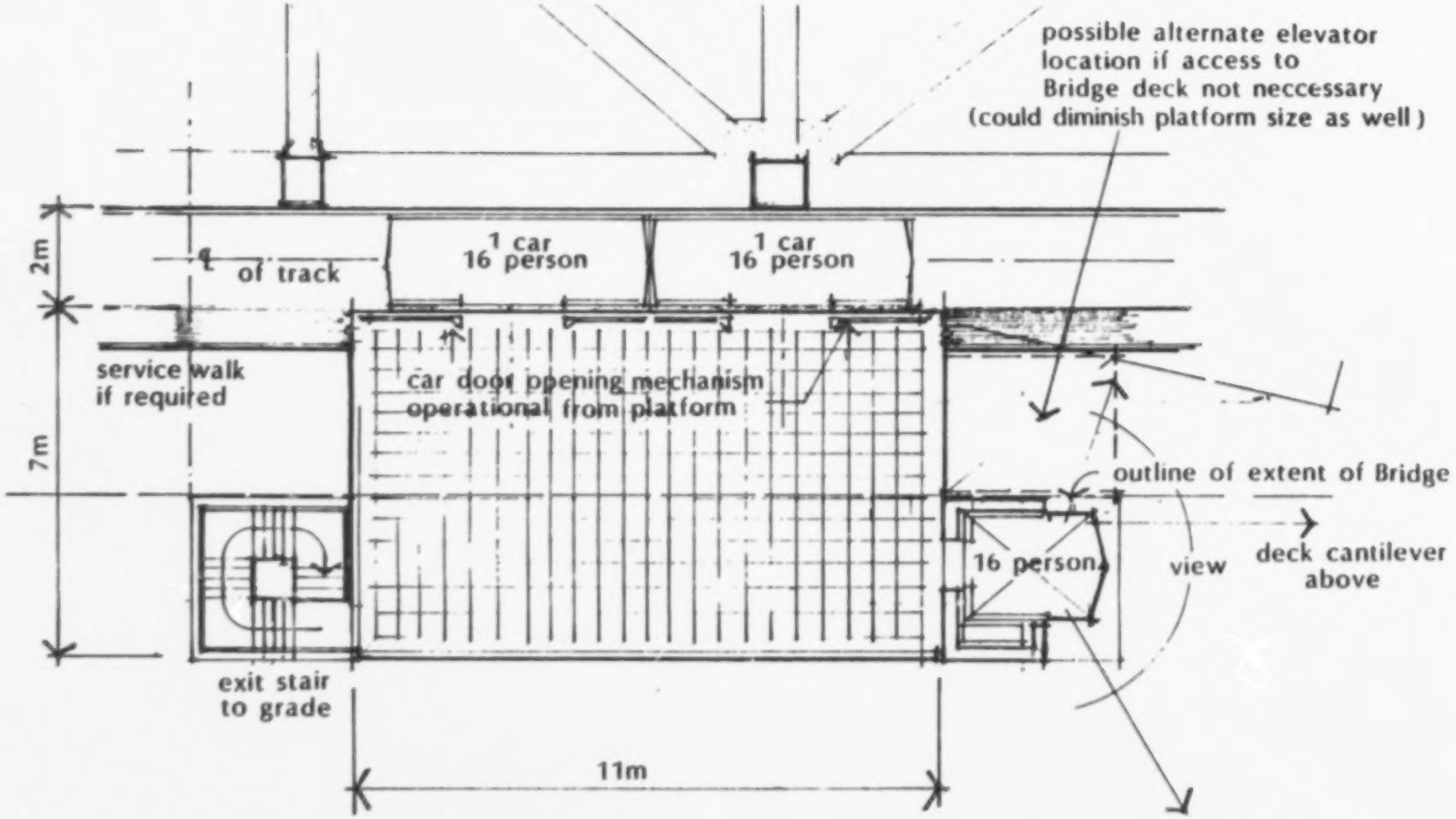
The proposed guideway cross section is illustrated opposite. The guideway consists of a steel structure mounted on the side of the bridge and suspended under the cantilevered bridge deck. The guideway width is 2.7 m including a 0.7 m wide walkway.

The guideway mounted equipment includes the Linear Induction Motor (LIM) modules and air bearing track.

The LIM modules are mounted along the track at approximately 2 m intervals. They are only powered when a vehicle is passing. Motor thrust and direction is controlled by electronic wayside controls to propel and brake the vehicles.

The air bearing track and resilient runners under the vehicles provide low friction support and guidance. The air bearing track is sectionalized and only the sections under the passing vehicle will be activated, synchronized by the wayside controls.

The electrical cables and pneumatic hoses will be located under the service walkway.



platform level

STATIONS

The two stations for the Granville Island transportation will be simple and practical in design. A layout of the station over Granville Island is shown opposite. The station platform will be accessible by both a glass enclosed elevator and a stair. The stations will be covered and protected from wind and rain. The station on the north end of the track between Pacific Avenue and Beach Avenue will be integrated in the new parking garage, with ramps to grade level.

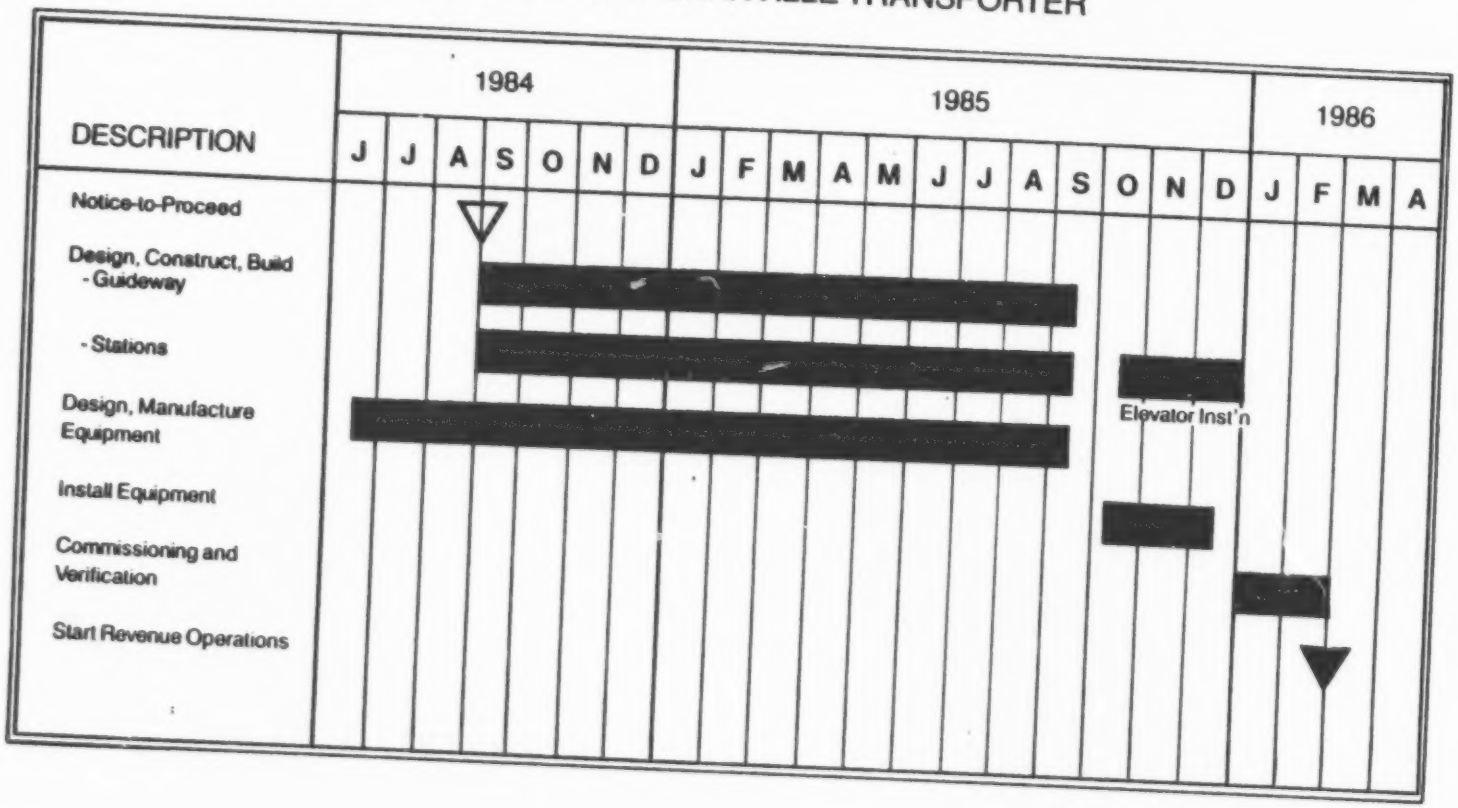
The system is designed for unattended operation. Station equipment includes displays to inform passengers about the mode of operation. Near the platform, there will be pushbuttons to request service during the on call operating mode. Intercoms or telephones in the stations, elevator cab and vehicles will be available for requesting emergency assistance.

There are two alternative station locations on Granville Island. Both allow for the potential development and integration of commercial functions in conjunction with the elevator and stair structure required for the station.

One possible station location is next to the present bus stop shelter on Johnston Street between the Creekhouse Building to the east and the Arts Club Theatre. The other location option is in front of the southern face of the Canada Chain Building above a triangular area, presently used for parking.

The Granville Island station will offer spectacular views of English Bay, the outer harbour and distant mountains.

IMPLEMENTATION SUMMARY SCHEDULE GRANVILLE TRANSPORTER



IMPLEMENTATION SCHEDULE

The Granville Island Transporter could be built and commissioned within 18 months of Notice to Proceed.

The implementation schedule opposite shows the major milestones and tasks. This schedule has been developed assuming a Notice to Proceed will be given by September 1, 1984.

All design work will begin immediately upon receipt of Notice to Proceed. During the first twelve months, the guideway and stations will be designed and constructed, so that installation of mechanical and electrical equipment can begin. The stations will be completed after 12 months, not including installation of the elevator.

Installation of equipment and track will require three months. Commissioning of the system and operations verification will also require 3 months.

The whole project can therefore be implemented in one and a-half years, with passenger carrying operation starting mid February of 1986, in time for the opening of Expo'86.

THE PROPOSED TEAM

The Granville Island Transporter concept design has been a joint effort of **Thompson Berwick Pratt & Partners, N.D. Lea Associates, Swan Wooster Engineering Company and the Urban Transportation Development Corporation (UTDC).** Thompson Berwick Pratt & Partners developed the system layout and station design, N.D. Lea and Swan Wooster undertook a preliminary assessment of the structural and guideway requirements, and UTDC has developed and will supply the transporter system, including the track, power modules, vehicles and communications and control systems. Implementation can be efficiently managed by the appointment of a systems coordination management consultant who, on behalf of the client, would have total responsibility for managing the design, engineering and construction of the guideway structures as well as the stations at either end of the system and the installation of the transporter system. UTDC would undertake the installation and be responsible for commissioning the system, training personnel and providing operations and maintenance support for the first two years.

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